Forest Health Technology Enterprise Team

TECHNOLOGY TRANSFER

Mating Disruption

Using Mating Disruption to Manage Gypsy Moth: A Review

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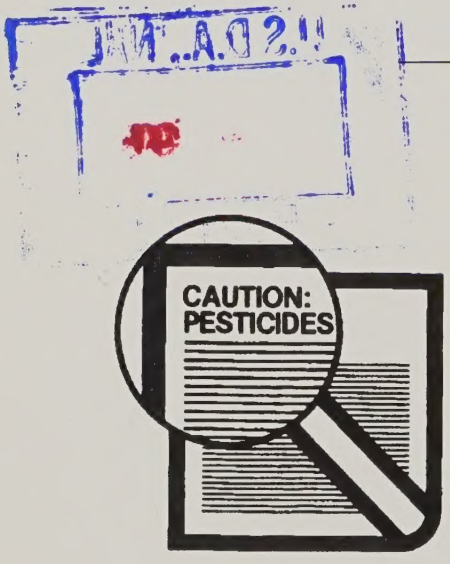

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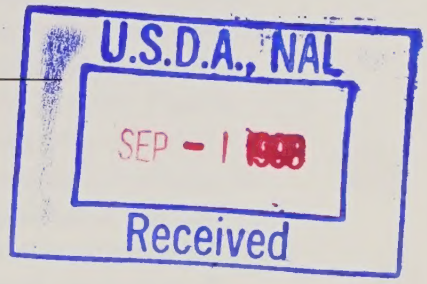
A Review



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Preface

This review is published as part of a joint USDA program conducted by three of its agencies — Forest Service, Agricultural Research Service (ARS), and Animal and Plant Health Inspection Service (APHIS) — to develop specific methods for managing sparse-density expanding populations of the gypsy moth, *Lymantria dispar* (L.). The program is supported through the efforts of the Gypsy Moth Mating Disruption Working Group (hereafter, Working Group).

The Working Group was formed in 1990 and is composed of members from the USDA Forest Service, ARS and APHIS; U.S. Environmental Protection Agency (U.S. EPA); Virginia Department of Agriculture and Consumer Services (VDACS); Rockbridge County Virginia Gypsy Moth Program; Hercon Environmental Co.; Biosys, Inc.; and Nalco Chemical Co. In 1997, Thermo Trilogy Company (Columbia, MD) acquired biosys, Inc., and Loveland Industries (Greeley, CO) replaced Nalco Chemical Co. as representing private industry. Through cooperative efforts, the Working Group conducts field and laboratory studies to solve problems associated with the use of mating disruption to manage sparse-density gypsy moth populations. It also provides technical assistance to improve the quality of operational programs involving the aerial application of pheromones for managing gypsy moth.

This version (January 1998) of *Using Mating Disruption to Manage Gypsy Moth: A Review* is an update of handbook FHM-NC-08-95 printed in December 1995. It contains all of the information included in the December 1995 version as well as the results of studies conducted in 1996 and 1997.

Contents

Introduction

Semiochemicals, also called behavior-modifying chemicals, are volatile chemicals emitted by organisms to transmit information to other individuals. When the organisms are the same species, the semiochemical is a pheromone. Pheromones that act as attractants cause an organism to move towards the chemical source.

Insect pheromones that act as sex attractants show promise for suppressing pest populations through mating disruption. The idea behind mating disruption is to create interference with the sex pheromone emitted by the female to a level at which the male has difficulty locating her.

Mating disruption is accomplished by adding artificial pheromone sources to the environment. The effect is creating an atmosphere concentrated with the attractive material or creating many odor sources. Consequently, the males become confused and are prevented from finding female moths.

Scientists first learned how to synthesize many pheromones in sufficient quantities for field evaluations in the early 1970's. In Europe experiments using pheromones to control major insect pests in fruit orchards were started in 1975. In the United States the first pheromone registered for use as a mating disruptant was for control of the pink bollworm, *Pectinophora gossypiella* (Saunders), in 1978. Ridgeway et al. (1990) did an in-depth review of a wide range of uses for pheromones and other behavior-modifying chemicals.

Preliminary demonstrations of the effectiveness of mating disruption were shown for several forest pests—the Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough); western pineshoot borer, *Eucosma sonomana* Kearfott; ponderosa pine tip moth, *Rhyacionia zozana* (Kearfott); several bark beetles; and the gypsy moth, *Lymantria dispar* (L.).

In the late 1980's the trend towards using more environmentally friendly control agents and developing prevention strategies for managing the gypsy moth resulted in greater emphasis on developing mating disruption. Concurrently, the 5-year congressionally mandated Appalachian Integrated Pest Management (AIPM) Gypsy Moth Project was initiated in a 38-county area in West Virginia and Virginia. A major emphasis of this project was developing technology, including mating disruption, for managing sparse gypsy moth populations (less than 10 egg masses per acre).

This review is a compilation of historical and current information on the use of mating disruption to manage sparse-density populations of the European strain of the gypsy moth. Included is information on development, registration, and formulations of the synthetic pheromone disparlure, as well as effects on nontarget organisms. Previously unpublished studies of efficacy, deposition, and residual activity of disparlure are reported.

Mating Biology of the Gypsy Moth

In the European strain of the gypsy moth, the adult male is guided to the flightless adult female primarily by pheromone, identified by Bierl et al. (1970) as Z-7,8-epoxy-2-methyloctadecane, also called disparlure. Although zig-zag flight along the plume of disparlure is the primary mechanism for initial orientation, other behavioral cues are important for successful location and recognition of a mate. Visual cues, principally those presented by tree trunks, are important in inducing landing and the walking search for a female. Recognition at close range and mating are evoked by contact cues such as wing tip touching. Thus, although location of the female over long distances is mediated by pheromone, additional visual and contact stimuli are critical to successful reproduction (Charlton and Carde 1990).

The gypsy moth is univoltine, that is, has one generation per year, and the mating season occurs over a 3-6 week period in late summer. Most mating normally occurs daily between 1000-1700 hours. Some males mate more than once, and some of the males do not mate at all (Mastro 1995). A small portion (about 20%) of the females in dense populations, and an unknown but probably small percentage in sparse populations, mate more than once. Females are capable of high pheromone release rates for 3 days but then their ability to release pheromone and mate decreases. Once mated, females stop releasing pheromone and begin ovipositing. Unmated females near the end of their life will lay unfertilized eggs.

Mating Disruption of the Gypsy Moth

The synthetic version of the gypsy moth sex pheromone used in mating disruption is structurally similar to the pheromone produced by the female gypsy moth. A 50:50 mixture of the (+) and (–) enantiomers (molecular structures with a mirror-image relationship) of disparlure has been applied using ground and aerial application methods. In both methods dispensers impregnated with this racemic mixture of pheromone release it slowly into the environment.

The ideal formulation of disparlure would release the pheromone at a constant rate and discharge all of the active ingredient in a specified period of time. The physical characteristics of the formulation and tank mix adjuvants have an effect on the discharge of disparlure. Variable meteorological conditions such as temperature and relative humidity, however, can exert unpredictable influences on disparlure release from a formulation.

For mating disruption to be effective, the synthetic pheromone must be present in sufficient quantities for the entire mating period. Since disparlure is volatile, denser than air, and is dispersed by air currents, complete initial coverage of an area is probably not essential. Due to the vertical distribution of females on tree trunks, however, there is a need for vertical distribution of the pheromone.

Failure of males to locate mates in air permeated with disparlure, probably results from desensitization of the chemoreceptors in the males' antennae, as well as from disorientation by following false pheromone trails or leaving the pheromone treated area (Carde and Minks 1995).

The mating disruption technique is more effective as gypsy moth populations decrease in density, because males locate females primarily by the pheromone at low population densities (Beroza and Knipling 1972, Knipling 1979). At high population densities males can more easily locate females using visual cues, as well as by chance encounters.

The gypsy moth is not an ideal candidate for mating disruption due to the high fecundity of females producing 300-1200 eggs per mass, the polygamous nature of males, and the clumped or aggregated distribution pattern of adult females, which is probably due to their sedentary nature and clustering at suitable larval resting and pupation sites. Nevertheless, some characteristics of the European strain of the gypsy moth are suited to the use of mating disruption, including the flightlessness of females, limited dispersal of the majority of males beyond a few hundred meters, low mating success at sparse densities, and the characteristic of having one generation per year. Unlike the European strain, some recently introduced gypsy moth females of the Asian strain are capable of strong flight, and how this characteristic would influence the usefulness of the mating disruption technique is unknown.

Assessing Biological Effectiveness of Mating Disruption

The effectiveness of mating disruption of the gypsy moth is assessed biologically on the basis of using several techniques in combination: counting life stages under bands, monitoring flight of males, monitoring females for mating success, examining eggs for embryonation, and conducting egg mass surveys. These techniques were used to determine efficacy in the methods development trials reported for 1990-1995.

Counting life stages under bands—Numbers of larvae, pupae and egg masses under bands (such as burlap) on tree boles at breast height are counted. A decrease in abundance or the absence of larvae and pupae as compared with levels in the previous year indicates effectiveness of mating disruption in the previous year. A decrease in abundance or the absence of viable egg masses in the treated area as compared with an untreated area indicates the effectiveness of mating disruption in the year of treatment.

Monitoring flight of males—Traps are baited with 500 µg of (+) - disparlure to attract males during the flight period and deployed at the rate of one trap per 15 acres. If mating disruption is effective, males will not be caught because they will not be able to locate the pheromone in the trap just as they will not be able to locate females. In the year disparlure is applied, the number of males captured does not provide an estimate of population density but rather a measure of the effectiveness of communication disruption.

Monitoring females for mating success —Virgin 1-day-old females are placed untethered in shelters—such as modified delta traps (triangular cardboard traps usually used to capture adult male gypsy moths). The inability of males to locate the females in the shelters (monitor females) as well as resident wild females from under bands indicates effectiveness of mating disruption.

Examining eggs for embryonation—Egg masses are collected from monitor females and resident wild females under bands, held an additional 30 days in an outdoor insectary under

ambient conditions, and then examined for the presence or absence of embryos. The absence of embryos indicates effectiveness of mating disruption.

Conducting egg mass surveys—A visual search for egg masses is conducted and egg masses are counted. Absence of egg masses or their presence in lower numbers indicates effectiveness of mating disruption.

Traps baited with disparlure have some competitive advantage over females in that traps emit pheromone continuously over the entire mating season. Traps do not, however, present all of the orientation and recognition cues that females do. Therefore a trap catches only 20-30% of the males that visit the area within 3 m of the trap (Carde 1996). Reduction in the number of males trapped after application of various disparlure formulations has not been equated with reduction in mating success. Monitor females provide a more direct measure of mating success. Such monitoring has not been directly related to changes in density of native egg masses, however, mainly because no accurate technique has been developed for quantifying egg mass densities in sparse populations.

Development of Mating Disruption—1971 through 1997

Before 1989 — Initial Development and Application

Federal and State agencies and private companies have attempted to use mating disruption to manage populations of the gypsy moth since 1971 (e.g., Granett and Doane 1975, Schwalbe et al. 1974, Stevens and Beroza 1972, Webb et al. 1988). Before 1989 various entities conducted mating disruption activities independently, with mixed results. Many research and operational trials of mating disruption were complicated by numerous problems, such as inappropriate and inconsistent formulations of disparlure, relatively insensitive evaluation techniques, and lack of data on seasonal release rates of disparlure. Nevertheless, the following generalizations were derived from these early efforts at mating disruption (Kolodny-Hirsch and Schwalbe 1990): (1) a direct dose-response relationship exists both for disruption of mating communication and for disruption of mating (Webb et al. 1988), (2) the degree of mating reduction is inversely related to male population density (Webb et al. 1988), and (3) a peak in mating occurs during peak male flight. In addition, in 11 of 15 mating disruption trials with the gypsy moth published between 1972 and 1988, evidence for mating disruption was based entirely on the reduction of male moths caught in traps and on the mating success of laboratory-reared or field-collected females placed in the test plots. In only one report were changes in native population trends statistically tested and shown to be significant (Beroza et al. 1974).

Numerous formulations containing the active ingredient (AI) disparlure were evaluated during these early years, for example, hollow plastic fibers (Conrel Inc.), gelatin microcapsules (National Cash Register Capsular Products, Stauffer Co., Penwalt Co.), and plastic laminated flakes (Hercon Environmental Inc.). In general, these formulations provided a relatively uniform distribution of pheromone under laboratory conditions. In field tests, however, the disparlure was inefficiently released, and major problems were encountered in the aerial application of these formulations due to the spray systems available for aircraft at the time.

In earlier trials, low doses of disparlure, e.g., 50 mg AI per ha (20 mg AI per acre), in various controlled release formulations reduced male trap catch for the entire season and in a few cases suppressed mating. In general, however, results were inconsistent and discouraging. In a dense population of gypsy moth, ground application of disparlure at doses of 5, 50 and 500 g AI per ha (2, 20 and 200 g AI per acre) dispensed from plastic laminate tape stapled on tree boles decreased mating success by 7%, 34% and 84% respectively, as measured against controls in small-plot tests (Schwalbe and Mastro 1988). Even in the plots treated with 500 g AI per ha some monitor females were mated, probably due to the high density of gypsy moth males, short range communication (i.e., visual cues) and chance encounters. In later trials, Webb et al. (1988) demonstrated more consistent efficacy by the use of 75 g AI per ha (30.4 g AI per acre) disparlure applied aerially to disrupt mating.

From 1983 to 1989 only one commercial product containing racemic disparlure, the plastic laminated flakes Disrupt II (Hercon Environmental Inc., Emigsville, PA), was registered by the U.S. EPA for use in mating disruption. Therefore, operational use of mating disruption was limited to use of these layered plastic flakes.

1989—A Transitional Year

In July 1989, an eradication program was conducted in Giles County, Virginia, with the aerial application of the bacterial insecticide *Bacillus thuringiensis* (*B.t.*) and the growth regulator diflubenzuron as the primary treatments, and on approximately 2,500 acres disparlure was applied in the form of Disrupt II at a dose of 30.4 g AI per acre (Leonard et al. 1992). The mating disruption technique was selected for that portion of the project area where the National Science Foundation had an ongoing study on behavior of dark-eyed junco (*Junco hyemalis hyemalis*). Since part of the diet of juncos is lepidopteran larvae, *B.t.* or diflubenzuron could not be used. The project area included uninhabited forest land ranging in elevation from 1,000 to 1,300 m, with oak as the primary overstory vegetation and gypsy moth populations below 10 egg masses per acre. An adjacent untreated area was used for comparison.

The mating disruption portion of this eradication effort used previously developed technology for dispensing and evaluating disparlure but also acquired new data on vertical deposition and release rates of Disrupt II. The 1989 trials are described here in detail because the methods were also used in 1990-1995.

Figure 1. *Specialized application equipment mounted under the wing of a Cessna 206 for dispensing the flake formulation of racemic disparlure (Disrupt II).*

Specialized equipment developed in the 1970's by Schweitzer Aircraft for applying flakes was mounted, one pod on each side, under the wing of a Cessna 206 (Fig. 1). The dispensing rate of the flakes is controlled by an

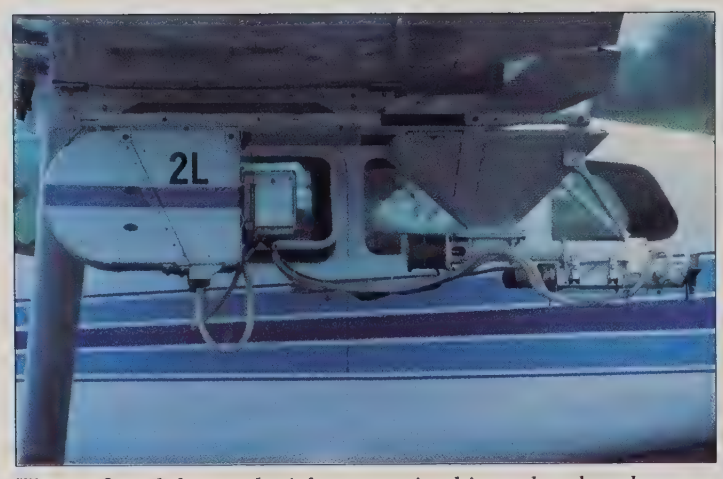

Figure 2. *Flakes and sticker are mixed in a chamber then dispensed through a spinner.*

auger, and the sticker is controlled by a pump and tubing system. The flakes and sticker are mixed in a chamber then dispensed through a spinner (Fig. 2). During gypsy moth suppression projects using an aqueous formulation, this aircraft typically is assigned a 75-foot swath width, but due to the inability of the motor controlling the auger on each pod to deliver sufficient flakes, a 45-foot swath was assigned to realize the desired deposit rate of approximately 41 flakes per square meter (3.7 flakes per square foot).

During characterization trials, the flake deposition pattern within the swath was uneven, with peaks occurring directly under the pods and valleys under the fuselage and wing tips. Additionally, the pod motors for augering the flakes and pumping the sticker malfunctioned periodically and bridging (binding) of the flakes in the hopper was a constant problem. During applications, a total of 165 g of flakes (dose of 30.4 g AI), talc powder to prevent bridging of the flakes, and 4 oz of the sticker/extender Gelva -1990 (Monsanto, St. Louis, MO) to adhere the flakes to the foliage were mixed and applied per acre. The flake treatment was initiated in July just before anticipated adult male flight. The size of the flake hoppers limited treatment to 125 acres per load at the 30.4 g AI dose.

Efficacy

No egg masses were found before treatment (spring 1989) in the pheromone treated and untreated areas, while both areas had similar male moth catches (summer 1988). In 1989 after treatment, no males were captured in the treated area, and 26% of the traps captured male moths in the untreated area. Pheromone traps placed on a 250 m grid for 2 years after treatment (1990 and 1991) captured one moth on the edge of the pheromone treated area in 1991 and an average of four moths per trap in the untreated area. Both of these areas were trapped from 1992 through 1995 on a maximum spacing of a 1-km grid. In 1995 the pheromone treated area was still relatively free of male moths, while populations in the untreated area had received insecticide treatment in 1993.

Laboratory-strain F_1 10K irradiated sterile gypsy moth females (male parent was irradiated with 10 Krads as a pupa) were used as monitor females. Sterile females were used to satisfy regulatory concerns because the project was located outside the quarantine regulated area. When mated with a normal male, these sterile females produce an egg mass that embryonates, but most eggs do not hatch. If these sterile females do not mate, an egg mass can be produced but it will not embryonate. Monitor females were deployed at 100 stations twice weekly for 3 weeks coinciding with male moth flight. They were left overnight and retrieved the next day. None of the monitor

Figure 3. *Deposition of green plastic laminated flakes on foliage.*

females were mated in the treated or untreated areas. This led to speculation that sterile females were not appropriate for use as monitors and plans to test an escape resistant mating station in which fertile females could be deployed when working outside of the quarantine regulated area were formulated.

Deposition

In addition to the efficacy results, a bucket truck and ground tarps were used to evaluate deposition of 10 times the normal application of flakes (1 × dose flakes containing disparlure and 9 × dose of blank flakes) applied to a 4 ha (10 acre) site within the disparlure-treated area. This high application rate was used to ensure detection of a sufficiently high number of flakes. Twenty overstory and twenty understory trees were sampled. Flakes were deposited throughout all layers of the canopy, including the understory foliage (Fig 3). Flakes were inventoried at 160 sampling points in the canopy and in 40 ground deposit nets. At application, only 10% of the flakes penetrated all levels of foliage and were deposited on the ground beneath the forest. Over 6 weeks, an additional 6% of the flakes fell to ground level indicating excellent performance of the sticker (Fig. 4).

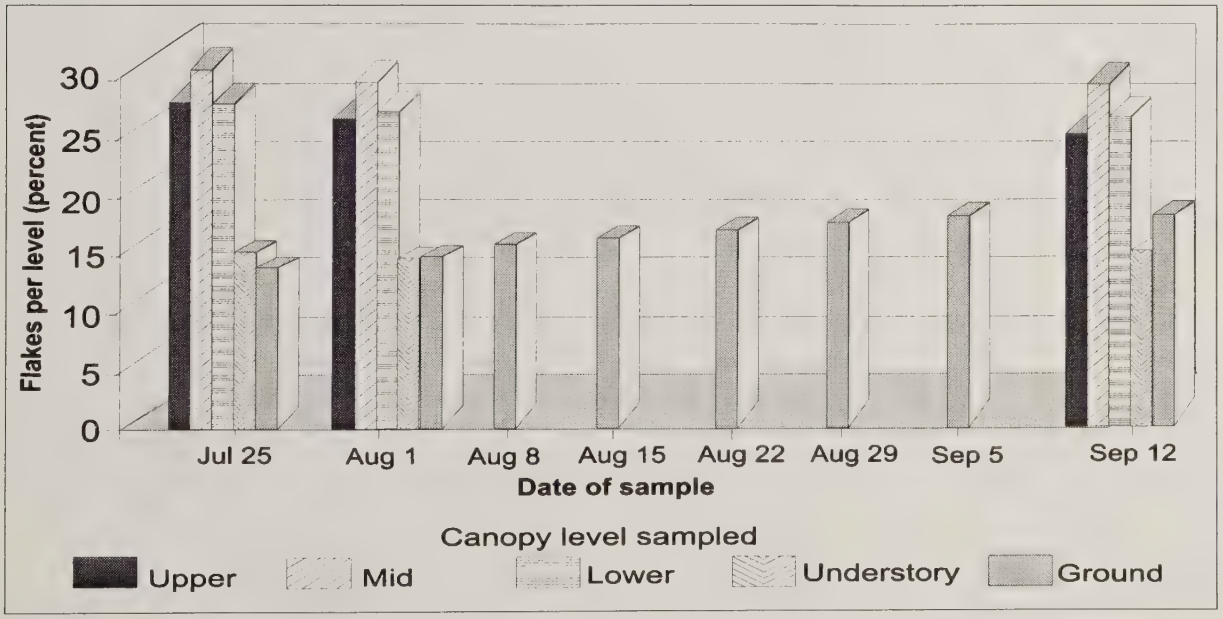

Figure 4. *Flake deposition after application of 10 times normal Disrupt II in Giles County, Virginia, 1989. The ground level was sampled on all dates. The canopy was sampled only on July 25, August 1, and September 12.*

Residual Activity

During aerial application, sections of black roofing paper were placed on the ground in open areas to collect flakes for release rate analysis. These flakes were weathered on the roofing paper placed beneath the forest canopy and collected weekly for 8 weeks. Initially the flakes contained 17% disparlure by weight. Results of gas chromatographic analysis of the flakes indicated that they lost approximately 65% of their disparlure content over the first 10 days, 10% over the next 20 days, and 12% in the last 26 days of the test. Moth flight started approximately 15 days after application. This rapid initial release of lure from the flakes was unexpected and prompted additional sampling to confirm suspicions that elevated temperatures on the dark surface of the roofing paper from which the flake samples were collected had increased the release of disparlure. On day 100 after treatment, 20 flake samples were collected from foliage in the sun, foliage in the shade, and roofing paper. On average the flakes collected from foliage contained twice as much lure as the flakes aged on and collected from the roofing paper.

Summary of 1989 Results

The Giles County project was considered a success as only one male moth was recovered from the pheromone treated area for 2 years after treatment (1990 and 1991). These efficacy results were better than anticipated based on the inconsistent operability of the pods, the nonuniform distribution of flakes, and the small proportion of disparlure released during moth flight and mating activity.

1990-1997 — Second Stage of Development and Application

The AIPM Gypsy Moth Project of the USDA Forest Service reviewed all available information gathered through 1989 and determined which information was adequate and what questions remained unanswered. This review showed the need for methods development and operational evaluation of mating disruption. This need led in fall 1990 to the formation of the Gypsy Moth Mating Disruption Working Group, which was composed of members from Federal, State, and county governmental agencies; and private companies.

The newly formed Working Group proposed a series of methods improvement projects for implementation over the next 7 years. The broad objectives of these efforts were to (1) refine techniques for evaluating efficacy and equipment for applying Disrupt II, (2) quantify the lowest efficacious dose and number of applications of Disrupt II, and (3) develop an additional formulation of disparlure that could be applied through conventional boom and nozzle spray systems. Therefore, unlike the separate activities conducted from 1971 to 1989, activities from 1990 through 1997 represent a concerted effort. Methods improvement trials are discussed by year in the following sections. Operational uses of Disrupt II are summarized in Table 1.

1990 — A New Bead Formulation

The studies initiated in 1990 had two specific objectives: (1) to evaluate the impact of a single yearly application of disparlure and of an initial double application of disparlure on gypsy moth

Table 1. *Acres of operational treatments using disparlure flakes, Disrupt II, applied at 30.4 g AI per acre to manage gypsy moth, 1989 through 1997.*

Year	Location	Acres treated
1989	Giles Co., VA	2,500
1990	Sequatchie Co., TN	200
1991	Roanoke/Bedford Co., VA	2,900
	Allegheny/Botetourt Co., VA	400
	Mercer Co., WV	1,700
Subtotal 1989-1991		***5,000***
1992	Bedford/Botetourt Co., VA	4,829
	Floyd/Carroll Co., VA	1,000
	Mercer/Monroe/Pocahontas Co., WV	4,230
Subtotal 1992		***10,059***
1993	Giles Co., VA	2,600
	Mercer Co., WV	350
Subtotal 1993		***2,950***
1994	Craig Co., VA	775
	Monroe Co., WV	3,385
	Raleigh Co., WV	270
Subtotal 1994		***4,430***
1995	Pulaski/Giles Co., VA	2,450
	Mercer/Summers Co., WV	259
	Franklin Co., OH	235
Subtotal 1995		***2,944***
1996	Halifax/Dare Co., NC	1,900
	Greensville/Southampton Co., VA	2,926
	Giles/Craig/Botetourt/Roanoke Co., VA	3,578
	Carroll Co., VA	425
	Monroe Co., WV	3,887
	Mercer Co., WV	355
	Unicoi/Carter Co., TN	252
	Sheboygan Co., WI	2,200
Subtotal 1996		***15,523***
1997	Southampton Co., VA	560
	Floyd Co., VA	567
	Roanoke Co., VA	5,151
	Allegheny Co., VA	1,227
	Greenbrier Co., WV	100
	Monroe Co., WV	1,156
	Summers Co., WV	2,052
Subtotal 1997		***10,813***
Total - All Years		**51,719**

mating success and population trends over 5 years, and (2) to field test an additional commercial disparlure formulation that could be applied through conventional boom and nozzle systems. Rockbridge and Augusta Counties in Virginia were selected as the project area for these method improvement evaluations for these reasons: (1) this area was within the AIPM project 2-km grid of pheromone traps, and male moth data were available for 1989 (average 27 moths per trap, range from 11 to 200 per trap); (2) county technical support personnel were already in place; and (3) isolated woodlots were abundant.

Disrupt II

Three woodlots (each 35-160 acres) were treated with two applications of flakes (Disrupt II) in 1990 only, each at a dose of 30.4 g AI per acre per application. Treatments were applied just before anticipated initial male flight (June 17) and before anticipated peak flight (July 20). Three additional woodlots were treated just before male flight in 1990 and again every year from 1991 through 1993 with a single application of flakes (Disrupt II) at a dose of 30.4 g AI per acre. An additional three woodlots were not treated. All applications of flakes were applied at 165 g per acre with 4 oz of Gelva-1990 as sticker and talc to prevent bridging.

Density of gypsy moth populations were estimated yearly using three techniques: surveying pre- and post-treatment egg mass densities (1/40 acre subplots on uniform 50 m grids); surveying larval, pupal and egg mass densities under burlap bands (checked when most gypsy moth caterpillars reached late instars and pupal stages, and again after the male flight period); and trapping male moths (one trap per 15 acres, with a minimum of three traps in woodlots smaller than 45 acres). To monitor mating success, laboratory-strain females were placed in modified delta trap mating stations in each woodlot at the rate of 30 females three times a week for 3 weeks during the peak moth flight period. The modified delta trap (not coated on the inside with adhesive, ends open, and female placed on a piece of burlap inside) was found to be the most escape resistant as well as maintained the attractiveness of the female to males (Fig 5). In addition to the laboratory-strain females placed in mating stations for monitoring, resident wild females under bands were monitored, and their egg masses collected and assessed for fertility within treated and untreated woodlots. A total of 1,165 1/40-acre subplots (2.5 - 4.6% of total woodlot area) was established for egg mass surveys (Leonhardt et al. 1996).

Figure 5. *Modified delta trap used as a mating station for monitor adult females.*

To assess relative competitiveness, laboratory-strain and resident wild females were deployed in a moderately dense population of gypsy moth located to the north of the study woodlots in Rockbridge County.

Efficacy

The efficacy results over all years (1990 through 1994) are presented in Chart A (pages 41-43). Population densities were significantly reduced by either the double application in 1990 or single application every year from 1991 through 1993. Compared with untreated woodlots, the abundance of immature life stages and fertilized egg masses under burlap bands, the percentage of mating success in monitored females, and the number of trapped adult males all remained low in woodlots treated yearly with one application of 30.4 g AI per acre (Leonhardt et al. 1996). The low degree of mating success in monitor and wild females indicated there was significant mating disruption in those treated woodlots in all four years of treatment. Although monitor females were not deployed in these woodlots in 1994, the year after the last pheromone treatment, all of the other measures of assessment showed that the gypsy moth population remained suppressed. In the woodlots receiving a double application, all measures of population density were low in the year of treatment (1990) and 1 year after treatment (1991). In 1992, however, the population began an upward trend although at a reduced rate of increase as compared with the untreated woodlots (Leonhardt et al. 1996). The evaluation of resident wild and laboratory-strain females in 1990 demonstrated similarity in their attractiveness, behavior and mating success. Therefore only laboratory-strain females were used in all future work (1991 through 1997).

Residual Activity

To evaluate consistency of Disrupt II over years, the release rates for the 1989 (used in Giles County) and 1990 (used in Rockbridge County) Disrupt II products were determined after multiple passes over 23 by 30 cm (9 by 12 inch) white canvas coated art paper cards (Strathmore Paper Co., Westfield, MA) placed on the ground in an open area at the airport. The cards were allowed to dry and were hung vertically on string beneath the forest canopy for aging. The amount of disparlure per flake was determined as a function of duration of exposure. Using this data, the calculated release rates for both products were slow and uniform over time and did not differ significantly (Fig. 6). Both the 1989 and 1990 Disrupt II products released only approximately 50% of their racemic disparlure content after 42 days, which is the approximate duration of the male moth flight period.

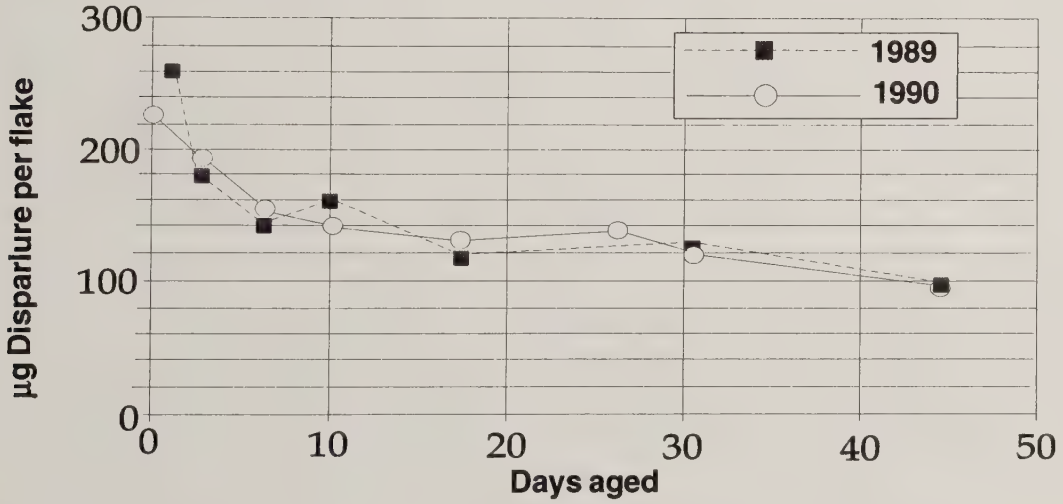

Figure 6. *Release rates of disparlure from Disrupt II flakes produced in 1989 and 1990.*

Bead Formulation

AgriSense (Fresno, CA) developed a new polymeric flowable bead formulation for mating disruption of pink bollworm in cotton. To determine the release characteristics of this bead formulation containing disparlure, laboratory evaluations were conducted by Leonhardt (ARS, Beltsville, MD) in 1990. The bead formulation released disparlure at a faster rate than did the flakes but field release and efficacy data were needed to support laboratory results.

Efficacy

A field test was proposed using this flowable bead formulation containing disparlure (AGRIS-1029). The bead formulation was to be applied to a 10 acre woodlot, to evaluate efficacy, and deposition and release rate profiles on foliage. A similar 10 acre woodlot was treated with flakes (1990 Disrupt II). The beads contained 40 % AI (by weight), and ranged from 50 to 800 microns with a volume median diameter (VMD)—the droplet size that divides the spray volume in half—of 275 microns. The tank mix consisted of 75 g of beads, 124 oz water, 2% (by volume) Gelva-1990, applied at 1 gal per acre to yield a dose of disparlure of 30.4 g AI per acre.

The application was attempted with a small fixed wing aircraft (Ag Cat) equipped with standard spray booms and flat fan nozzles. This aircraft spray configuration had been used effectively to apply the flowable bead formulation for pink bollworm, although the desired dose rate of 30.4 g AI per acre of disparlure (AGRIS-1029) required the application of between 21 to 53 times the amount of beads per gallon of tank mix as had been used effectively for pink bollworm.

Numerous problems were encountered during airport characterization trials: (1) beads collected on the flat fan diaphragms, and the nozzles would not shut off, (2) beads clumped together clogging the nozzles, boom and pump motor, and (3) beads would not stay suspended in the tank mix. Eventually the proposed 10 acre treatment had to be abandoned and a few trees near the airport were sprayed.

Residual Activity

To characterize release rates, approximately 50 23 by 30 cm (9 by 12 inch) canvas coated paper cards were placed on the ground in an open area at the airport, and each group sprayed repeatedly with the bead or flake formulation. The cards were allowed to dry and were hung vertically on string beneath the forest canopy for aging. Samples (3-5 cards) were taken after 0, 3, 7, 14, 21, 28, 42, and 56 days. Analyses were conducted on a Model 6C-9A gas chromatograph (Shimadzu Instruments, Columbia, MD) with results calculated as micrograms per flake or per bead. Residual disparlure in beads and flakes recovered from the spray cards showed that the bead formulation delivered about 3-4 times as much disparlure to the air over the 42 days of the test than did the flakes (Fig. 7). Although the beads released considerably more lure than the flakes, more than 70% of it was discharged prior to the start of male flight (day 10). The accumulated disparlure delivered by both formulations showed the beads released 22% of their content and the flakes 14% of their content during peak moth flight.

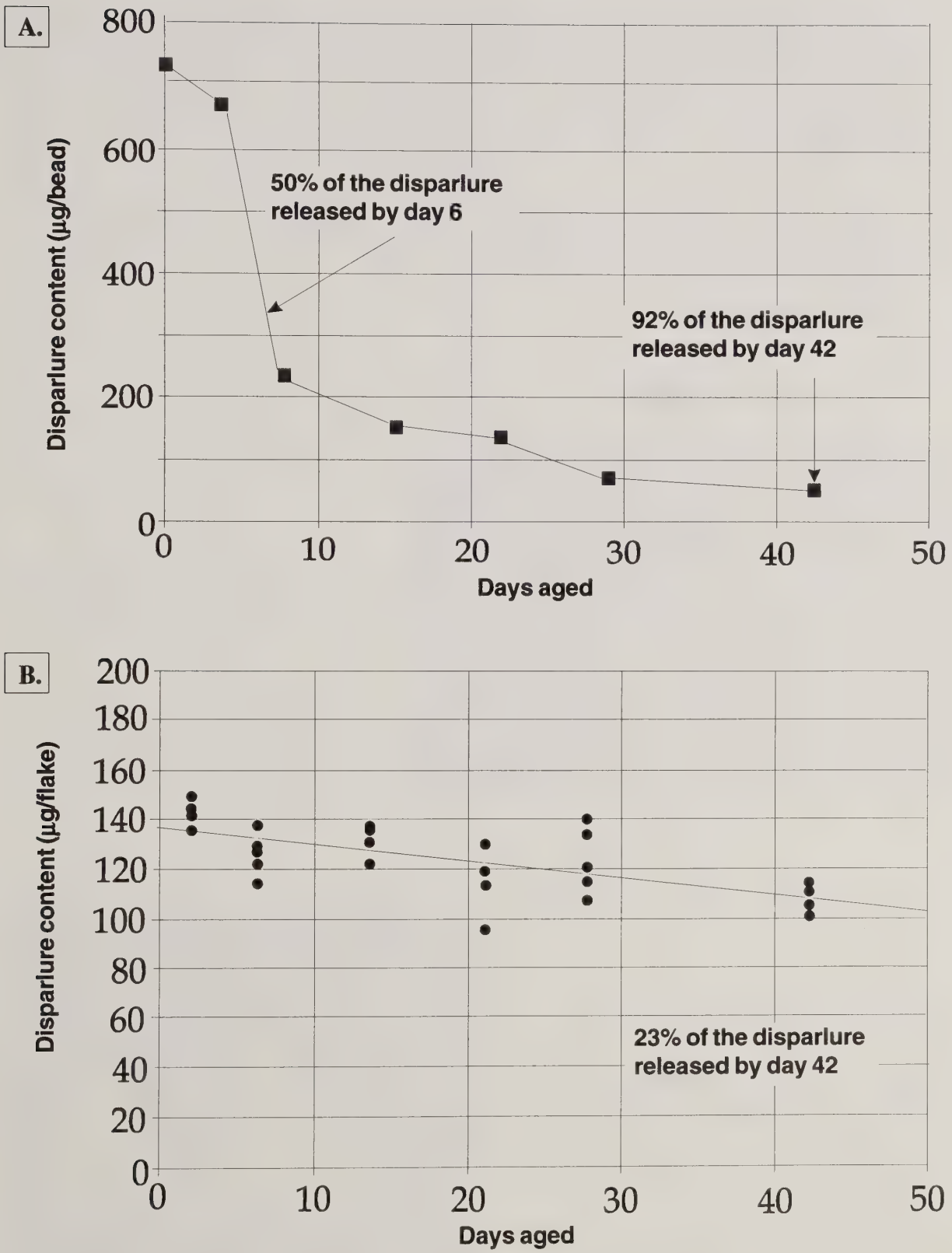

Figure 7. *Disparlure content in (A) AgriSense beads and (B) Disrupt II flakes picked from spray cards aged in the field, Rockbridge County, Virginia, 1990.*

Over 42 days, the beads released more than 90% of their total disparlure content, but the release was not at a constant rate. Over the same time period the flakes released 23% of their total lure at a slow but constant rate.

Deposition

During the airport trials, a few trees were sprayed with the bead formulation, to evaluate its adhesion to foliage. Of the total number of beads that originally adhered to foliage only approximately 20% remained 18 days after application.

Laboratory Evaluations

In fall 1990, an evaluation was conducted in the laboratory (APHIS Otis Methods Development Center) using the bead formulation to identify a suitable viscosity modifier to suspend the beads and a sticker to adhere the beads to foliage. Various tank mixes were applied to potted red oak seedlings and allowed to dry for various times before the application of rain. Before and between the rain events, the number of beads present within marked areas on replicate leaves were counted visually under a microscope.

The viscosity modifiers Nalquatic and StaPut (Nalco Chemical Co., Naperville, IL) provided favorable suspension of the beads. Nalquatic and StaPut acted as thickening agents and when each was combined with 2% Bond sticker (Loveland Industries, Greeley, CO) made the most promising tank mixes.

After the most promising tank mixes were identified, additional laboratory tests were conducted to determine if any of the tank mix additives significantly affected release of disparlure from the beads. All of the additives slightly reduced the initial release rate from the beads but there was no significant differences in release rates between the additives.

Additionally, the influence of bead size on release rate was investigated. As expected, the smaller beads released disparlure faster than did the larger beads.

Summary of 1990 Results

Results of trials conducted during 1990 indicated that the flakes were efficacious, releasing disparlure at a constant but slow rate. Flake application equipment problems persisted (e.g., bridging of flakes, uneven deposition of flakes beneath the aircraft) (Fig 8). The flowable bead formulation released disparlure erratically and too fast, probably because the majority of the beads were too small (106-205 microns). The rapid

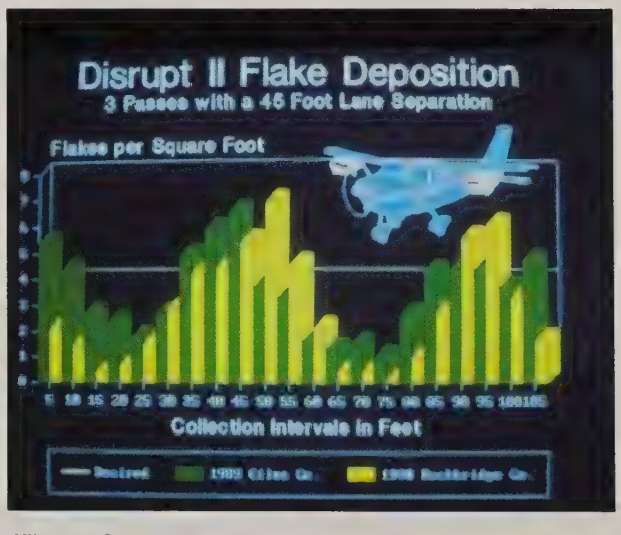

Figure 8. *Uneven deposition of flakes beneath application aircraft.*

release of lure documented in 1990 led to the conclusion that double applications of beads, 10 to 14 days apart, would be required in all subsequent applications in order to cover the entire flight period with adequate disparlure to disrupt mating. The tank mix (Gelva-1990) used with the beads plugged standard aircraft boom and nozzle systems. Subsequent laboratory tests identified 2% Bond sticker combined with either Nalquatic or StaPut as promising tank mixes. All additives slightly reduced the initial release of lure, but there were no differences in release among the tank additives.

The modified delta trap mating station design developed in 1990 was used for all subsequent methods improvement projects. Laboratory-strain females were found to be equally competitive with wild females in attracting males and mating success. Therefore only laboratory-strain females were used in all subsequent tests.

1991 — Methods Development for the Bead Formulation

Airport Trials

In January 1991, a series of field trials were conducted at the APHIS Aircraft Operations facility in Mission, Texas. The objectives of the trials were to evaluate (1) tank mixes that provided favorable deposition, rainfastness and suspendability of beads in laboratory evaluations in 1990, and (2) various types of dispensers for application of the beads.

Figure 9. *CP nozzle with check valve used to apply bead formulation of racemic disparlure.*

The viscosity modifiers Nalquatic (0.25%) and StaPut (20%) with Bond sticker (2%) provided favorable suspendability and deposition of beads when tank mixes were aerially applied to 23 by 30 cm (4 by 5 inch) Kromekote paper spray cards. Several nozzle systems (e.g., hollow cone, open pipes extending from the boom) were evaluated for sprayability of beads with CP nozzles (C and E Enterprises, Mesa, AZ), performing with minimal clogging (Fig. 9). The degree of clustering of beads (thought to be an important factor for release rate of lure and adhesion to foliage) on spray cards appeared to be similar for the StaPut and Nalquatic tank mixes when applied using CP nozzles with check valves and set on the largest orifice with 90° deflection plate. These inexpensive nozzles are used to apply various pesticides to agricultural crops and easily attach to standard spray booms.

Efficacy

In June and July 1991, six blocks, each approximately 50 acres, were treated in Rockbridge County, Virginia: three blocks with a double application (12 days apart) of beads containing 40% racemic disparlure at a dose of 30.4 g AI per acre per application (75 g beads per acre

per application) and three blocks with a double application of Disrupt II at 30.4 g AI per acre per application (165 g flakes per acre per application). The beads were applied using a Cessna 188 (AgTruck) equipped with six CP nozzles, 75 ft swath, and tank mix consisting of 20% StaPut, 3% Bond, and 77% water. A Cessna 206 equipped with 2 pods was used to apply the flakes using a 45 ft swath and tank mix consisting of 4 oz of Gelva-1990 per acre. Three additional blocks were not treated.

Prior to 1991, the diatomaceous earth that Hercon adds to the flakes to reduce static electricity during the manufacturing process was sifted out prior to final packaging of the Disrupt formulation. Starting in 1991, some of the diatomaceous earth (12 - 14% by weight) was left in the flakes in order to prevent bridging of the flakes in the hoppers. This eliminated the need to add talc to the hoppers.

AgriSense adjusted the bead size so that there were fewer beads in the 106-250 micron range and more beads in the 300-425 micron range (Fig. 10). The objective was to reduce the release rate of disparlure from the beads (Fig. 11) without creating so large a bead as to cause clogging in the spray system as well as problems with large beads adhering to foliage.

The 1991 posttreatment efficacy results for the bead treatment indicated that it was effective, as no fertilized egg masses were found under burlap bands or in 1/40-acre subplots and none of the monitor females were mated (Chart B, page 44). The bead treatment effect evident in 1991 was not evident in 1992, 1 year after treatment.

The 1991 posttreatment efficacy results for the flake treatment were complicated by gypsy moth populations expanding in the general area surrounding the northernmost block (fertile egg masses were recovered in and surrounding the treated block) while no fertile egg masses were recovered in the other two flake-treated blocks (Chart B). Also, none of the monitor females in the flake-treated blocks were mated. In 1992, no treatment effect was evident.

Deposition

As part of the 1991 evaluations, two forested sites received 10 times the normal application of flakes or beads to allow recovery for determination of sticker performance on foliage. The formulations were applied in the same tank mixes used on the efficacy blocks. On day 12, coinciding with the start of peak flight, 79% of the flakes and 68% of the beads remained attached to foliage. On day 56 after application, only 59% of the flakes and only 28% of the beads remained attached to the foliage, due to failure of the sticker.

Residual Activity

Emission rates of disparlure from beads or flakes were essentially the same whether the sample was collected from foliage or canvas coated cards. On day 42 after application, the flakes still contained about 60-70% of their original disparlure content (Fig. 12A) and on day 88 in late September the flakes still contained 40% of their original lure content. Additional analysis showed that 2.5 µg per flake of disparlure or about 2% of the original dose remained after 12 months of exposure in the field. In contrast, on day 42 after application, the beads

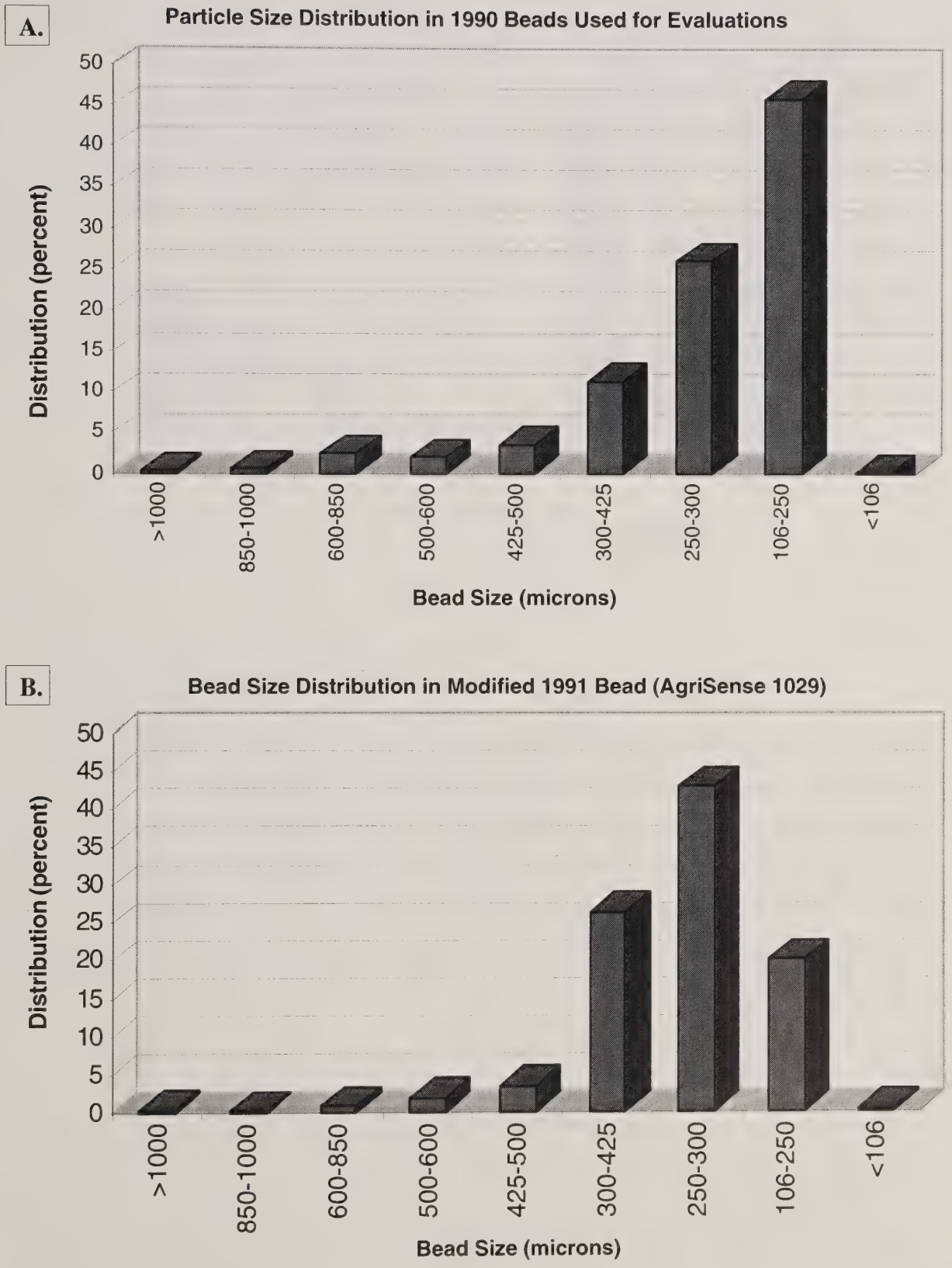

Figure 10. *Size distribution of beads produced (A) in 1990 and (B) in 1991.*

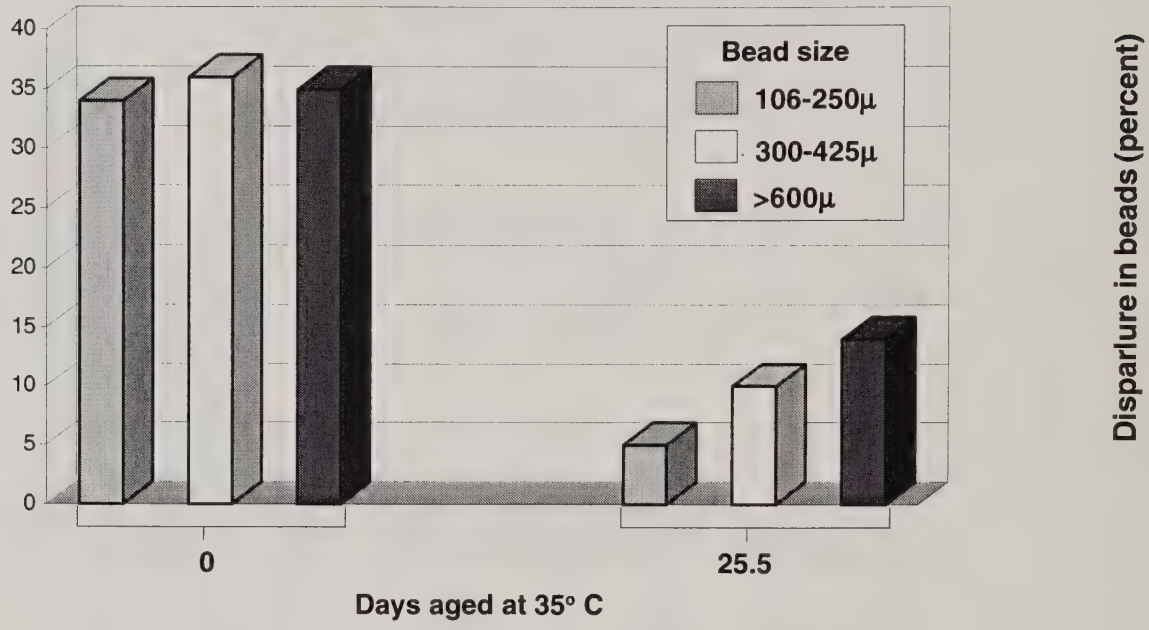

Figure 11. *Release rates of disparlure from three sizes of beads.*

still contained about 10-15% of their original disparlure content (Fig. 12B). Although the release rate from the beads was relatively rapid, the new formulation of larger beads was effective in slowing the release of lure when compared with the 1990 formulation. The two applications provided high amounts of disparlure during peak male moth flight, however, the amount of disparlure released over 90 days was about threefold higher from the beads than from the flakes (Fig. 13A). At peak moth flight, the beads released a maximum of approximately 1.9 g per day per acre while the flakes released 0.6 g per day per acre (Fig. 13A). Although the beads are more efficient than flakes at discharging lure, the rate of discharge is not constant over time. The discharge rate from a single application (Fig. 13B) of beads drops from about 1.4 g per day per acre initially to about 0.8 g per day per acre after 1 month (June 17 - July 18). In comparison, the release rate from the laminate flakes over the same period in 1991 was nearly constant at 0.3 g per day per acre from a single application (Leonhardt et al. 1992).

Summary of 1991 Results

Results of trials conducted during 1991 indicated that standard spray booms with CP nozzles were usable for applying beads, and the 20% StaPut and 3% Bond tank mix provided improved suspendability and adhesion of the beads to foliage (over the Gelva-1990 tank mix), although additional carriers needed to be evaluated for use with the beads. The flakes were not sticking to foliage as well as in the past, probably due in part to the increased volume of diatomaceous earth (12-14% by weight) in the Disrupt II formulation, which was effective in preventing bridging. Also, the pod application equipment continued to perform erratically, in

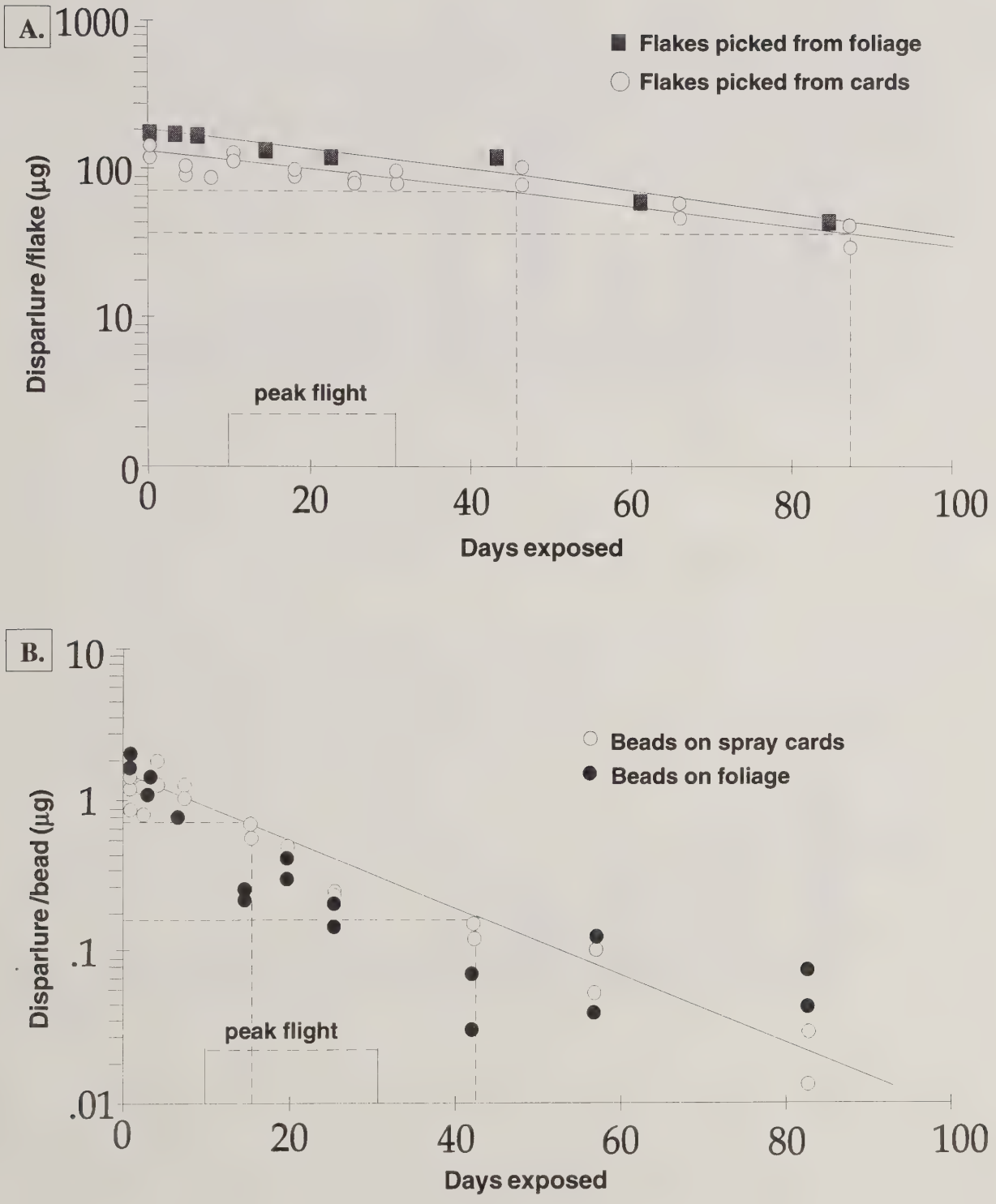

Figure 12. *Disparlure content (A) of flakes and (B) of beads recovered from spray cards and foliage.*

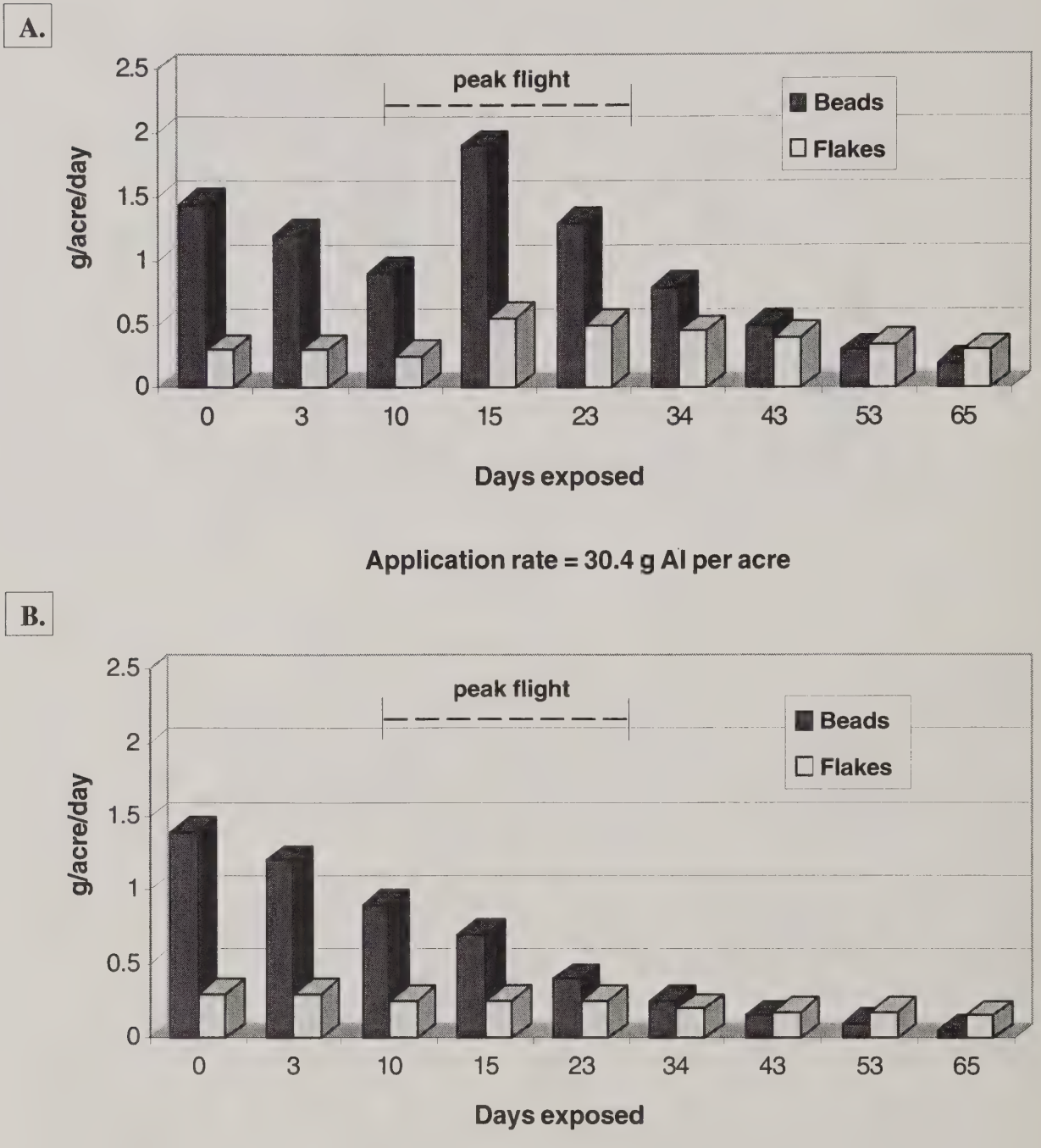

Figure 13. *Average disparlure emitted from beads and flakes, Rockbridge County, Virginia, 1991.*

spite of mechanical modifications to upgrade the augering systems and in spite of the application of a Teflon coating to the spinner blades on each auger to prevent buildup of flakes and sticker. The larger beads produced for the 1991 season were effective in slowing the release of disparlure. The more efficient release profile of the beads compared with flakes means there is potential for reducing the total dose of beads while maintaining a daily emission rate equivalent to the standard lure (30.4 g AI) of flakes. Results of trials conducted during 1991 indicated that the flakes and beads were efficacious in the year of treatment but not 1 year after treatment.

Although the flakes still contained 40% of their disparlure after 88 days in the field, at the start of the next year they contained only 2% of their original disparlure content and were unlikely to emit enough disparlure to affect mating in the year after application. Sampling from cards yielded the same release rates on sampling from foliage, therefore all subsequent tests used card samples only.

1992 — Dose-Response Evaluations

Airport and Laboratory Trials

In April 1992, the previously used thickening agent StaPut at 20% volume with 3% Bond and another thickening agent TX 7719 (Nalco Chemical Co.) at 10% volume without Bond were each mixed with the beads to evaluate ease of mixing, suspendability of beads, and sprayability and weathering on spray cards and potted oak seedlings. These studies were conducted at the APHIS Aircraft Operations facility. The results showed that TX 7719 provided suspension of the beads comparable to that provided by StaPut, but more importantly once the TX 7719 had dried wash-off was minimal (less than 5%) even with rainfall events of more than 1 inch. The effect of TX 7719 on the discharge of disparlure from beads was evaluated in the laboratory and results indicated that beads mixed with TX 7719 release disparlure at the same rate as when mixed with StaPut or water only when held in an environmental chamber at 35° C for 30 days.

Efficacy

A pre-season (June) evaluation of dose versus degree of mating disruption (dose-response) was set up to determine the minimum rate of disparlure (grams per day per acre) that is effective in disrupting mating. The doses of racemic disparlure were 30, 15, 6 and 3 g AI per acre, with one application per block per dose. One block was not treated. Of the average block size of 200 acres, only the center 20 acres were used for evaluation. The bead formulation (instead of the flake formulation) was selected for evaluation because of its rapid release characteristics and because it would provide more "point sources" of pheromone than would the flake formulation at a given dose. An AgTruck equipped with 6 CP nozzles was used to apply the beads in a 60 ft swath at 1 gal per acre. Over the course of the 8-week evaluation a simulated population of 10 gypsy moth mating pairs per acre (10 mating pairs per acre at each of 4 times over a 2-week interval) was created by deployment of newly emerged

adults from laboratory-strain pupae supplied by APHIS and held outdoors at the evaluation site until eclosion. Males were released on tree boles and females were placed in mating stations (Leonard 1994).

All doses appeared to suppress mating to a similar extent. Only 0.05 % of the egg masses recovered from the treated blocks were fertile while 24% of those recovered from the untreated block were fertile. These results were unanticipated and confusing based on the wide range of doses and previous efficacy results of other investigators, although the combination an evenly distributed simulated low population versus a clumped or aggregate distribution in nature and cold rainy weather probably limited adult activity and confounded the sensitivity of the evaluation. Of the 720 males released into the untreated block only 67 (9.3%) were recaptured. No males were captured in any of the treated blocks.

Under more typical summer weather conditions, the test was repeated with essentially the same results.

A post-season (August) dose-response evaluation was conducted using doses of 0, 3, 6, 15 and 30 g AI per acre. The percentage of fertile egg masses recovered was .69% in the treated blocks and 43% in the untreated block. Of the 720 males released into the untreated block only 139 (19.3%) were recaptured. No males were captured in any of the treated blocks.

An additional efficacy evaluation was conducted during the gypsy moth mating season (July) to determine whether two applications of beads at 6 g AI per acre would disrupt mating. This dose was selected based on 1991 release rates: an application of beads at 6 g AI per acre initially released disparlure at the same rate as an application of flakes at 30.4 g AI per acre and was more cost effective. A second application of beads, 10-14 days after the first application, was needed to augment the dose of racemic disparlure since the beads release their pheromone content quickly (Chart C, page 45). Also, the 6 g AI per acre dose for each of two applications was considered economically competitive ($8 - $13 for AI and formulation for 12 g dose) with other operational control options ($15 per application per acre for the gypsy moth nucleopolyhedrosis virus product Gypchek and $5 per application per acre for *B.t.*). Six blocks (three treated and three untreated) were established in Rockbridge County, Virginia.

In 1992, fertile egg masses per acre were 0 in all three treated blocks compared with an average of 3.6 fertile egg masses in all three untreated blocks (Chart D, page 46). The percentage of monitor females mated was substantially reduced by the treatment, but mating was not entirely disrupted as fertile egg masses were recovered from under burlap bands in one of the bead plots in the year of treatment. In 1993, two of the treated blocks had 0 fertile egg masses per acre and the other 12.6, whereas the untreated averaged 28 egg masses per acre.

Deposition

Sticker performance of two bead tank mixes (10% TX 7719, and 20% StaPut and 3% Bond) and one flake tank mix (Gelva-1990 at an increased rate of 6 oz per acre) was evaluated on

blocks, treated at 30.4 g AI per acre. Each tank mix was applied multiple times to ensure good coverage. Eight days after treatment and coinciding with the start of moth flight, 80% of the beads and TX 7719; 89% of the beads, StaPut and Bond; and 93% of the flakes remained adhered to foliage. At the conclusion of the test (44 days after treatment), 63% of the beads and TX 7719; 60% of the beads, StaPut and Bond; and 71% of the flakes remained adhered to foliage.

Residual Activity

Sets of 35 canvas coated cards were sprayed with beads mixed with 10% TX 7719, or with 20% StaPut and 3% Bond and hung in the woods for periodic collection, to determine disparlure release rates. The beads in both tank mixes released lure at approximately the same rate and at a slightly slower rate than in 1991, probably due to the fact that the bead size distribution again shifted slightly upwards. Both tank mixes released approximately 50% of the lure by day 20 and 70% of the lure by day 42.

Summary of 1992 Results

In and out of season tests using simulated populations of 10 mating pairs per acre indicated that a 3 g AI per acre dose of beads was equally effective as a 30 g AI per acre dose in disrupting mating. The beads applied at 6 g AI per acre for each of 2 applications during the normal gypsy moth mating season provided mating disruption. Results of trials conducted during 1992 demonstrated that the sticker/extender TX 7719 provided adequate suspension of beads and provided equal adhesion of beads to foliage and release rates as did the 20% StaPut and 3% Bond mixture. For all subsequent tests with beads TX 7719 was used as the sticker/extender because less volume is required which results in less cost. The bead size shifted upward again in 1992 bringing to attention the fact that different bead lots are not exactly repeatable in terms of bead size distribution or release rates.

The pods used to apply the flakes continued to malfunction. Therefore, a contract was developed with K&K Aircraft (Bridgewater, VA) to modify the Hercon pod system or to develop another dispensing system for flakes that could be used on small (e.g., AgCat) and large (e.g., Twin Beach) aircraft.

Flakes applied in 1992 were mixed with 6 oz Gelva-1990 per acre and contained 5% (by weight) diatomaceous earth. This reduction in diatomaceous earth and increase in sticker volume improved the adhesion of flakes to foliage when compared with flakes applied in 1991.

1993 — Reduced Doses of Disparlure

Efficacy

To determine the efficacy of reduced doses of disparlure, a trial was conducted in Rockbridge County, Virginia, using a total of 12 blocks: 4 blocks treated with beads applied at 6 g AI per

acre per application in two applications; 4 blocks treated with flakes at 20 g AI per acre in one application; and 4 blocks untreated. The 6 g AI per acre per application dose of beads applied in two applications was used because results were favorable in 1992. These blocks used for the 1993 evaluations had been used as untreated blocks for previous pheromone evaluations (Thorpe et al. 1998). The treatments were blocked on the basis of population density (numbers of immature life stages under burlap just prior to treatment). Two of the four replicates in each treatment had more dense populations than would normally be selected for mating disruption.

Mating was disrupted in all treated blocks (greatest in the two replicates with lowest pretreatment densities) when compared with untreated blocks, although fertile egg masses were recovered in two flake-treated blocks and three bead-treated blocks (Chart E, page 47). An average of 1 male moth per trap was captured in the flake-treated blocks, 3 male moths per trap in the bead-treated blocks, and 200 male moths per trap in the untreated blocks. In general, there were no differences in efficacy between the bead or flake treatments. After treatment egg mass surveys conducted in 1993 yielded an average of 28, 6.7 and 4.4 egg masses per acre respectively in the untreated, flake and bead treated blocks (Thorpe et al. 1998). In 1994 the gypsy moth populations in the untreated blocks continued to increase above 1993 levels (average 402 males per trap and 63 egg masses per acre) and increases also occurred in the treated blocks (an average 38 males per trap and 13.9 egg masses per acre in flake-treated blocks, and an average 107 males per trap and 11 egg masses per acre in bead-treated blocks). In 1995 populations in all treated and untreated blocks decreased sharply, probably as a result of the increased incidence of the fungus *Entomophaga maimaiga* and nucleopolyhedrosis virus in the general area (Thorpe et al. 1998).

Deposition and Residual Activity

Release rates were evaluated by aerially applying flakes with 6 oz of several sticker/ extenders (Gelva-1990, Gelva-2333) and a Nalco product (RA-8554) to 23 by 30 cm (9 by 12 inch) canvas cards for analysis of residual disparlure content and to foliage for sticker performance. Monsanto decided not to manufacture sticker Gelva-1990 beyond this year; therefore, evaluation of other products was needed. The cards were hung in a nearby wooded area for aging. Periodically, 3 to 5 replicate cards for each treatment were removed for determination of residual disparlure content in the flakes and beads. Beads applied at 1 gal per acre with 10% TX 7719 were sprayed on 23 by 30 cm (9 by 12 inch) spray cards for analysis of residual disparlure content as well as on foliage to evaluate adhesion.

Gelva-2333 was selected to replace Gelva-1990 based on good performance on a sticker and no noticeable changes in release characteristics. At 13 and 47 days after treatment, 90% and 84% of the flakes and Gelva-2333 were still adhered to foliage. This compared favorably with the flakes and Gelva-1990 mix where 88% and 72% were still adhered to foliage on days 13 and 47. The Nalco 8554 did not perform well with only 51% and 28% of the flakes remaining at days 13 and 47. The beads and TX 7719 mix did not perform as well in the past when only 57% and 31% of the beads still adhered 13 and 47 days after treatment.

Shin-Etzu Chemical Co. (Tokyo, Japan) provided a batch of an experimental slow release powder formulation and a commercially produced carrier for mixing with the powder in the tank. The powder contained racemic disparlure (9.5% AI) and was evaluated only for release rates on canvas cards, as the powder did not stay suspended in the carrier.

K & K Aircraft developed a system for dispensing the flakes, which consisted of one augering unit mounted beneath each side of the front wing and one unit beneath the fuselage. The system was developed for use on a Twin Beech with the potential of carrying sufficient flakes to treat approximately 3,000 acres per aircraft load. The system was evaluated at the airport during characterization trials but has never been used operationally. The swath width was 125 feet with peaks and valleys of deposition beneath the aircraft. This system needed (1) additional development to prevent clogging of the auger with flakes and sticker, and (2) larger holding tanks in the fuselage.

Summary of 1993 Results

Results of trials conducted during 1993 demonstrated that lower doses of disparlure (beads applied at 6 g AI per acre in each of two applications and flakes applied at 20 g AI per acre in one application) suppressed mating when compared with untreated blocks but did not prevent the production of some fertile egg masses in the blocks with higher population densities. Therefore, there was a need to reevaluate these doses of disparlure against low density populations. Gelva-2333 was selected to replace the soon to be discontinued Gelva-1990 as a sticker for the flakes. Suspension of the Shin-Etzu powder when mixed with the carrier and water in the tank was unsatisfactory. Also, the pheromone release rate from the powder was more rapid than the release rate from beads. These unfavorable characteristics resulted in a request to Shin-Etzu to modify their formulation and carrier before the initiation of future trials. The prototype system for dispensing flakes from large aircraft developed by K & K aircraft needed additional modification but was not pursued due to anticipated limited use of mating disruption over large areas in the next 5 years.

1994 — Increased Doses of Disparlure

Efficacy

Twelve blocks, four per treatment, were established farther south in Rockbridge County, Virginia, where there were less dense gypsy moth populations as determined by the capture of fewer male moths. These blocks were not isolated woodlots as were used in the past, but part of the general forest. Each block was approximately 100 acres with only the center 20 acres used for evaluation. The treatments were (1) beads at 15.2 g AI per acre with 10% TX 7719 (now designated Biogrip or 93SD155) in 1 gal per acre for each of two applications; (2) flakes at 30.4 g AI per acre (175 g of flakes and diatomaceous earth per acre) with 6 oz Gelva-2333 per acre for one application; and (3) untreated. Increased doses for both flakes and beads were used in 1994 because in 1993, even though lower doses of disparlure in both flakes and beads suppressed mating, fertile egg masses were produced in blocks with higher population densities. The beads manufactured for use in 1994 again increased in size. This emphasized the continuing problem of variability in bead size distribution between manufacturing lots.

The treatment blocks were established on the basis of the number of life stages found under burlap bands just prior to treatment.

The 1994 posttreatment results indicated that gypsy moth populations were effectively suppressed by both formulations; however, neither treatment was 100% effective in all blocks (Chart F, page 48; Thorpe et al. 1998).

Deposition and Residual Activity

The release rate and stickability of the larger beads were compared with the 1993 beads for release rate of disparlure on canvas cards and for deposition on foliage. The beads were applied at the 30.4 g AI per acre dose in 1 gallon per acre with 10% Biogrip.

No differences were detected in the percentage of disparlure released over 30 days for "old" beads (77%) and "new" beads (74%). Also, there was no detectable difference in adhesion to foliage.

In 1994, some nozzle clogging was encountered using the larger beads. After each load the CP nozzles were cleaned, and usually at least one of the outer nozzles was completely plugged.

Summary of 1994 Results

Results of methods improvement trials conducted during 1994 demonstrated that the bead and flake treatments suppressed population in the treatment year (1994) as determined by the number of fertile egg masses and egg masses per acre recovered in the treated versus untreated blocks. There were no detectable differences between the 1993 beads and the 1994 beads based on release rates and adhesion to foliage. Unfortunately, the 1994 beads applied at 15.2 g AI with 10% Biogrip clogged CP nozzles. Preliminary thoughts concerning the cause of this problem were larger sized beads, unpublished change in the Biogrip additive, pH of the water in the tank mix, or a combination of these factors. The original pods manufactured for Hercon by Schweitzer aircraft in the 1970's were no longer reliable for use. The applications were plagued with breakdowns, primarily of the motors and motor controls for the flake augers. This performance of the original pods during the methods improvement trials was in contrast to more efficient performance of a much modified set of pods (i.e., with new motors and motor controls, a different design of augers, and larger flake hoppers) developed and used by Harold's Flying Service (Leland, IL) to apply the flakes to operational blocks.

1995 — Monitoring of Blocks Treated in 1994

No new efficacy and residue trials were initiated in 1995, but monitoring continued in blocks treated in 1994. The bead and flake treatments provided comparable population suppression (as compared with untreated plots), but results were complicated by an increased incidence of the fungus *Entomophaga maimaiga* and nucleopolyhedrosis virus, which also suppressed the gypsy moth populations in the treated and untreated blocks (Chart F, page 48).

In response to plugging of CP nozzles by beads in 1994, a contract was developed with Schiffer Flying Service (Ovid, MI) to apply several tank mixes containing the bead formulation from the ground and air. Several nozzle/atomizers (e.g., flat fan, hollow cone, Micronair) were used to apply the bead formulation. Micronair AU-5000 atomizers (without screens) (Fig. 14) performed well and did not plug during ground and aerial trials. The other nozzle systems (including the CP nozzles) plugged during application using ground equipment.

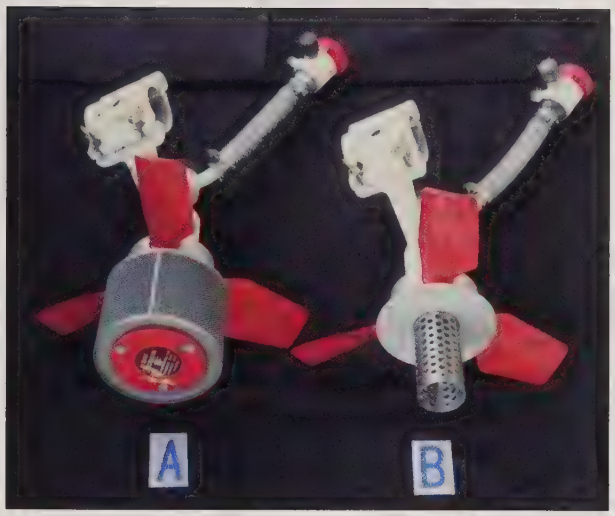

Figure 14. *Micronair AU-5000 atomizer (A) with cage screen used to apply insecticides and (B) without cage screen used to apply the bead formulation of racemic disparlure.*

Summary of 1995 Results

The increasing incidences of gypsy moth fungus and virus throughout Rockbridge and Augusta Counties, Virginia, further complicated the 1994 efficacy trials. It was decided not to initiate additional trials in 1996 until another area could be located with suitable low density gypsy moth population, modifications were completed to equipment for applying the flakes, and nozzles and tank mixes for applying the beads were reevaluated.

1996 – Evaluation of Additional Tank Mixes

Laboratory Trials

In the laboratory (APHIS Otis Methods Development Center), the tank mixes were deposited on seasoned foliage of potted red oak seedlings, and the plants were exposed to accumulated rainfall totaling 5.0 inches. A surfactant, TX 8815 (now designated Nalco 8815), that had earlier shown promise in preventing clogging of nozzles and aiding in mixing did not appreciably contribute to suspendability of the tank mixes evaluated and substantially increased wash-off of the standard tank mix. Of the tank mixes tested, the following four were most resistant to wash-off: (1) Biogrip, Nalquatic, and Nalco 8815, (2) Biogrip and Nalquatic, (3) Bond and Nalquatic, and (4) Bond, Biogrip, Nalquatic, and Nalco 8815.

Airport Trials

At the airport (APHIS Aircraft Operations), the Bond and Nalquatic tank mix (with and without 0.5% Nalco 8815) were selected for evaluation in an aircraft based on performance during laboratory trials. Nalco 8815 did not aid in keeping beads in suspension once mixed but did aid in the initial mixing of beads into a slurry. The Micronair atomizers without cages did not malfunction using these tank mixes.

Field Trials

An AgTruck was used to aerially apply large volumes of several tank mixes to experimental blocks in Rockbridge County, Virginia, in July 1996. The Bond and Nalquatic mix was chosen as the basis for evaluation due to its higher resistance to wash-off as compared with the standard (Biogrip). Each tank mix was applied through CP nozzles and AU5000 Micronair atomizers. Mixes were evaluated with and without Nalco 8815.

Clogging did not occur in CP nozzles or Micronair atomizers with any of the tank mixes. Past efficacy trials in which clogging occurred used CP nozzles with stainless steel bodies. These trials used CP nozzles with plastic bodies. Flow dynamics of the bead mixes through plastic bodies is different than through steel bodies (discussion with C and E Enterprises, Mesa, AZ). Further evaluation of the types of nozzle bodies is needed.

Both types of nozzles were configured to deliver a range of droplet sizes. Over an 8-week period after spraying, beads on foliage were counted to determine wash-off. None of the tank mixes applied through Micronair atomizers performed well. The best performing mix was 0.75% Nalquatic, 3% Bond, and 0.5% Nalco 8815 in water. When applied through CP nozzles set at maximum deflection and at maximum orifice size, this mix resulted in greater retention of beads on foliage than when applied through Micronair atomizers set at VRU of 12 and 90° blade angle with cages removed.

Retention of beads on foliage:

Days after application	CP nozzle	Micronair atomizer
14	90%	71%
28	80%	55%
42	50%	31%
56	35%	1%

The addition of Nalco 8815 surfactant did not cause undue foaming and appeared not to have increased wash-off of beads from foliage.

Summary of 1996 Results

Increased incidence of the gypsy moth fungus dramatically reduced gypsy moth populations throughout Rockbridge County and continued to complicate evaluation of previous efficacy trials. Evaluations of various tank mixes showed that combinations of Nalquatic, Bond, and bead mixes in water, with and without Nalco 8815, could be applied through CP nozzles with plastic bodies and Micronair atomizers without cages with no clogging.

Wash-off data for the Nalquatic, Bond, and Nalco 8815 tank mix compared favorably with the original 1993 wash-off data for the Biogrip tank mix.

1997 – Additional Trials of Flake Formulations

Efficacy

Because of concerns over delayed U.S. EPA registration of the bead formulation, the Working Group's focus shifted back to evaluation of the flake formulation. Based on results of earlier tests with hand-applied pheromone dispensers (Kolodny-Hirsch and Schwalbe 1990), it was originally concluded that any successful pheromone dispenser must be distributed throughout the forest canopy to be effective. The effect of dispenser distribution on the efficacy of mating disruption, however, has never been determined experimentally for the Hercon flakes. To distribute the flakes throughout the canopy, a sticker is required to adhere the dispensers to foliage for the duration of male flight. The mixing and application of flakes and sticker requires special equipment and frequently results in application problems. If flakes could effectively disrupt mating when applied without sticker, application could be simplified and costs reduced.

Twelve blocks that supported very low gypsy moth populations were established in the northern half of Rockbridge County, Virginia. Four of these blocks were treated with the standard flake tank mix, which consists of Hercon Disrupt II at 75 g AI in 9.9 oz of Gelva-2333 per ha and 3% diatomaceous earth. Four blocks were treated with flakes at the same dose and diatomaceous earth alone, and four controls were left untreated.

Biological efficacy was assessed using techniques described on pages 3 and 4. USDA milk carton traps to catch males and delta traps to deploy monitor females were placed both at ground level (2.5 m) and in the forest canopy (approximately 19 m). Burlap bands and pre-season and post-season 0.01 ha (1/40 acre) fixed-radius egg mass surveys were used to evaluate population levels and trends.

Communication between males and females was suppressed but not severed on treatment plots as measured by the number of males caught per trap per day. Average capture was 0.00013 males/trap/day on plots with sticker, 0.02 males/trap/day with no sticker, and 0.25 males/trap/day on control plots. Communication suppression was more successful in plots treated with sticker than in plots with no sticker. Mating success, as measured by the percent of fertile egg masses recovered from deployed females, was substantially higher in control plots (9.3%) than in either treatment (1.9% in plots with no sticker, and 1.4% in plots with sticker), and there appeared to be no difference between treatments. These combined data are ambiguous in that they do not show clear differences between the sticker and no-sticker treatments.

Alternative Tank Mix

Although the flakes have consistently been shown to adequately disrupt mating in efficacy trials in the past, the application equipment used to apply the flakes (dispenser pods developed in the 1970's by Schweitzer Aircraft and modified by Hercon Environmental, USDA APHIS, and Harold's Flying Service) is expensive, specialized, and performs inconsistently. A slurry of flakes in an appropriate carrier that could be applied with conventional spray equipment would offer an advantage.

In 1997, field trials evaluated a tank mix slurry using a new carrier, LI108 (Loveland Industries, Greeley, CO). LI108 is both a thickening agent and adhesive; therefore, no other adjuvants were used in this mix. The slurry was pumped through (1) special pinch valves and 8050 Tee Jet flat fan tips fitted to adjustable stainless steel bodies and (2) large diaphragm check valves with 8085 Tee Jet flat fan tips and round orifices. Some clogging did occur in the stainless steel valve bodies, and boom pressures were lower than desired; however, the slurry passed through both nozzle configurations well and there was positive shutoff. Unfortunately, when the flakes remain in the slurry there is a release of pheromone from the flakes into the slurry and, subsequently, to the air. Tests are underway to determine these release rates. Additional field testing of various slurry and nozzle configurations, as well as weatherability studies of the LI108 flake slurry, are planned for 1998.

Summary of 1997 Results

Results of the sticker versus no-sticker efficacy tests were inconclusive, but provided some evidence that it may not be critical for pheromone dispensers (e.g., Hercon flakes) to be applied to a target area in such a way that they adhere to foliage. Under some circumstances it may be possible to simplify application procedures and reduce application costs by using a tank mix with no sticker. The Mating Disruption Working Group identified this area of inquiry as a high priority for 1998.

The Hercon flake pods worked well for applying the standard mix with sticker, and no clogging occurred. The no-sticker mix was also successfully applied, except that, despite initial attempts to calibrate the system, the pods appeared to be putting out the total amount of material before the plot was actually finished. Although no specific factor could be identified as causative, a combination of factors could have contributed to this phenomenon, including these: (a) slight changes in calibration, (b) inaccurate acreage estimates, (c) delayed initiation or termination of pod auger operation or both, (d) flake dribbling after shutoff, and (e) overlap of previous swaths (the aircraft was fitted with a global positioning guidance system, but it was not functioning properly at the time of application).

Preliminary tests of an alternative tank mix (LI108-flake slurry) applied through specially designed nozzles attached to conventional spray equipment are encouraging, although the rapid leaching of pheromone from the flakes into the slurry needs to be resolved.

Current Disparlure Formulations and Use

Disrupt II

The current formulation of disparlure flakes, Disrupt II (Hercon Environmental Co., Emigsville, PA), was granted full registration by the U.S. EPA (Reg. No. 8730-55) in 1992. It contains a different plasticizer than the earlier formulation, whose registration was granted in October 1983 (EPA Reg. No. 8730-6) but not renewed in 1989. The current label specifies application of 30-40 g AI per acre to forested and residential areas (more than one house occurring per 10 acres).

The Disrupt II controlled release formulation of disparlure consists of multilayered plastic flakes or confetti, each 1/32 by 3/32 inch (1 by 3 mm) (Fig. 15). The flakes contain 18.5% AI of racemic disparlure. The active ingredient is implanted and protectively sealed in a layer between outer polymeric layers. The inner layer serves as a reservoir of the active ingredient, which migrates continuously through the permeable barrier layer. The flakes themselves contain 18.5% AI but they are packaged with diatomaceous earth (3% by weight), therefore the label for the final product is 17.9% AI. The flakes are mixed and applied with 4 oz per acre of the sticker/extender Gelva-2333. This mix is applied using an augering system modified from the system originally developed by Schweitzer Aircraft.

Figure 15. *Plastic laminated flake product, Disrupt II.*

The flakes are applied at 30.4 g AI per acre (170 g flakes per acre) in one application at the estimated start of adult male emergence. On average the flakes release approximately 30-40% of their pheromone by day 42 after treatment. At the 30.4 g AI per acre dose, 0.3 g per acre per day is released over 2 weeks. The release rate is consistently low during the male moth flight period; therefore, much of the pheromone is released after the flight period and is wasted. The acrylic multipolymer resin emulsion Gelva-2333 (replaces Gelva-1990, which is no longer produced by Monsanto) is the sticker/extender mixed with the flake formulation. This sticker/extender has two major components: (1) an adhesive agent to adhere the flakes to foliage or other plant surfaces and (2) a surfactant. The specific components are found on the inert ingredient list provided by U.S. EPA and are considered exempt from the requirement of a tolerance when used as an inert ingredient in a pesticide formulation applied to growing crops. This sticker/extender, which was first used in 1994, has not been as intensively evaluated as Gelva-1990 but seems to perform equally well. In general, about 80% of the flakes deposited remain adhered after 42 days of exposure.

Disrupt II is delivered in 5 gallon buckets or plastic bags (approx. 18.7 lb or 8.5 kg) each containing sufficient flakes to cover 50 acres at the dose of 30.4 g AI per acre. The cost to incorporate the disparlure into and manufacture the plastic flakes is approximately $8 to $20 per acre, depending on the quantity ordered, which does not include the cost of the racemic disparlure (also approximately $12 to $20 per acre). The plastic components of the flakes can persist in the environment for 10-15 years, but usually are not noticed due to their small size, green color, and minimal deposition (average 4 per square foot). When applied using the original hoppers developed by Schweitzer aircraft, each load will treat a maximum of 125 acres. When applied using the system modified by Harold's Flying Service, each load will treat approximately 400 acres.

Decoy GM

An application to register the Decoy GM bead formulation of disparlure was submitted by biosys (Columbia, MD) to the U.S. EPA in February 1995. In 1997, Thermo Trilogy Corporation (Columbia, MD) acquired biosys and is pursuing registration of the bead formulation.

The Decoy GM controlled release formulation of disparlure is a flowable bead formulation consisting of an open-pore polymer containing 34.04% AI of racemic disparlure. The beads range from 50 to 1000 microns with a volume median diameter (VMD)—the droplet size that divides the spray volumes in half—of approximately 275 microns. The particle size distribution of the beads varies for different production runs and this will affect the release characteristics. The beads appeared to release pheromone at a rapid rate although recent data indicates a release rate similar to flakes. The most widely used bead tank mix consists of 90% water, and 10% Biogrip (Nalco Chemical Co., Naperville, IL). It is applied at 1 gal per acre using AU-5000 atomizers without cage screens, or using CP nozzles with plastic bodies attached directly to the aircraft boom (without using a connector) and set on the largest orifice and 90° deflection plate.

The beads are applied at 15.2 g AI per acre in each of two applications, the first at the start of adult male emergence and the second to coincide with peak male flight. These beads rapidly release disparlure (75% over 8 weeks) although not at sufficient levels beyond the first 3 weeks. The beads release 50% of the AI by day 20 and 70% by the end of the season. Approximately 40% of the beads are lost from foliage over the season. Decoy GM is delivered in aluminum lined pouches containing 750 g of beads per pouch, which is sufficient to treat 17 acres at 15.2 g AI per acre. The bead formulation costs approximately $3.00 per acre, which does not include the cost of the racemic disparlure (approximately $12 to $20 per acre).

The suspending agent Biogrip (93SD155) is an aqueous acrylamide/acrylate polymer that has been used since 1992 with the bead formulation. Biogrip must be added to a water slurry of the beads to suspend them in the tank mix and to adhere them to the foliage. Biogrip's components also appear on the U.S. EPA ingredient list exempting it from the requirement of a tolerance. During one field trial, Biogrip caused milky stains on some car finishes, which required buffing or compounding for removal. Also, preliminary laboratory evaluations indicate that Nalquatic (0.75%) and Bond (3%) added to a water slurry of the beads provide better suspension in the tank mix and comparable adhesion to foliage. Therefore, recommendations for operational use of beads remains limited until tank mix and release rate problems are resolved.

Operational Use

Although the current Disrupt II flake product has been used operationally since 1990, many of the minor problems encountered with this product then still exist today. One of the problems is the slow release of the pheromone during the application year—specifically, during the male moth flight period. Then much of the pheromone is released after male moth activity and is consequently wasted. This problem requires the application of a high dose (30.4 g AI per acre) of disparlure with its associated high costs. The application equipment continues to perform erratically, although recent upgrades in the motors for the flake augering system and enlargement

of the flake hoppers have improved overall performance. The pods still mandate special aircraft requirements: at least a 24 volt electrical system, high wing for pilot to observe proper functioning and FAA approval. The persistence of the three-layer plastic laminate in the field continues to be an environmental concern about the application of flakes to residential areas. Hercon is evaluating, in the laboratory, a slow release flake formulation consisting of biodegradable plastics, as well as a paper matrix for use with racemic disparlure.

The Decoy GM flowable bead formulation, which is not registered by the U.S. EPA, has been aerially applied only during methods improvement projects and one pilot project. One of the major problems with the beads is the fast release rate of the active ingredient and, therefore, the need for a double application at additional cost. Maintaining optimum suspendability and stickability for the bead formulation is difficult; the recommended sticker/extender Biogrip needs additional evaluation relative to car finishes and may be discontinued.

Effects on Nontarget Organisms

The toxicity of insect pheromones to mammals is relatively low, and the U.S. EPA requires less rigorous testing of these products than it requires of insecticides. Therefore the toxicity data on disparlure is limited (Beroza et al. 1975, USDA 1995). Data regarding the toxicity of disparlure to animals or humans after subchronic or chronic exposures were not found in the available literature. Moreover, the acute toxicity of disparlure for endpoints other than mortality is poorly characterized (USDA 1995). Cameron (1995) reported an apparent persistence of disparlure in the human body based on attractancy to male gypsy moths for a minimum of 16 years.

In one laboratory exposure study, concentrations of racemic disparlure greater than 100 mg per liter of water resulted in some mortality of the test population of rainbow trout and bluegill (USDI Fish and Wildlife Service 1972). This should not be interpreted to mean that racemic disparlure is toxic to fish when used for mating disruption of the gypsy moth, only that excessively large doses might be toxic.

Few studies appear in the published literature on the potential effects of disparlure on invertebrates.

Conclusions

The mating disruption technique should be used only to manage isolated or area-wide low density populations of the European strain of the gypsy moth. The exact biological parameters for its successful use have not been identified, although since 1990 there have been several successes in reducing populations (compared with untreated areas) within a range of low level populations. Criteria currently recommended for its use are these: (1) traps should capture no greater than 30 male moths per trap, and the average capture should be less than 15 per trap in the year before treatment, (2) populations should be well delimited (i.e., at least nine traps per square mile), (3) the treated area should be at least 5 miles from a source of large numbers of migrating male moths, and (4) the treated area should be large enough to offset anticipated male moth migration

(e.g., at least 2,500 ft on a side). In operational uses, monitoring for treatment effectiveness is the same as that used with traditional insecticides on eradication projects (e.g., delimiting grids of at least 9 traps per acre deployed for at least 2 years after treatment). However, with mating disruption, 0 captures in the year of treatment does not necessarily equate with successful mating disruption. Rather, the captures in the year after treatment are used to evaluate effectiveness.

Costs associated with the manufacture and application of racemic disparlure and Disrupt II have been high compared with costs associated with aerial application of traditional insecticides.

Additionally, the cost of monitoring in methods development areas (e.g., Rockbridge County) is quite high. The use of females obtained as pupae from natural populations or laboratory-strain to monitor mating success is labor intensive in holding the pupae until adult emergence, in placing and collecting 1-day-old females at monitoring locations, and in determining mating and embryonation of the collected females and egg masses. Laboratory experiments and field evaluations indicate that monitor females, both laboratory-strain and wild, are comparable in attractiveness to wild male populations. Although intensive surveys for native egg masses indicate efficacy, such surveys are time consuming and expensive, and due to difficulty of sampling, egg mass surveys alone do not demonstrate efficacy (Roelofs 1979).

In spite of numerous successes in using Disrupt II to reduce gypsy moth populations, basic questions remain concerning the behavior of adult male gypsy moths in locating and mating with females, the spatial and temporal distribution of racemic disparlure, and the dose-response relationship of disparlure and effective mating disruption. The mating disruption technique has great potential for managing low density populations of the gypsy moth without associated impacts on nontarget organisms.

Summary

The use of pheromones to manage pest species has proven an effective technique in agriculture and forestry. Insect pheromones that act as sex attractants are used to suppress pest populations through mating disruption. This publication is a compilation of historical and current information on the use of mating disruption to manage sparse-density populations of the European strain of the gypsy moth.

Mating Biology of the Gypsy Moth

The mating disruption technique is more effective as populations decrease in density since at higher population densities males can locate females visually, by chance encounter, as well as by following plumes of pheromone emitted by females. The gypsy moth has one generation per year, and the mating season occurs over a 3-6 week period in late summer. Adult flight activity and mating are temperature mediated but most mating normally occurs daily between 1000-1700 hours.

Mating Disruption of the Gypsy Moth

The identification and production of the synthetic gypsy moth sex pheromone (Bierl et al. 1970) or disparlure provided the opportunity to manage gypsy moth populations by mating disruption. Failure of males to locate females in air saturated with disparlure probably results from desensitization of the chemoreceptors in the males' antennae, as well as from disorientation by following false pheromone trails or leaving the pheromone-treated area (Carde 1996). The gypsy moth is not an ideal candidate for mating disruption due to its high fecundity. In addition, males are highly polygamous, and natural distribution patterns of adult females are not random but clumped or aggregated. Good characteristics of the European strain of the gypsy moth for mating disruption include flightless females, low mating success of females at sparse densities, limited dispersal of the majority of males beyond a few hundred meters, and one generation per year. Because some recently introduced females of the Asian strain of the gypsy moth are capable of flight, this strain may be less suited to the use of mating disruption.

Development of Mating Disruption — 1971 through 1997

Since 1971, many attempts have been made to use mating disruption to manage populations of the gypsy moth. Kolodny-Hirsch and Schwalbe (1990) reviewed the results of research and operational trials before 1989. In general, these results were inconsistent in terms of efficacy and formulation performance, and disparlure release profiles were not monitored during the treatment year.

In 1989, an eradication program was conducted on 2,500 acres in Giles County, Virginia, using the Disrupt II plastic flake slow release formulation (Hercon Environmental Inc.). The flakes were applied at a dose of 30.4 g AI per acre of racemic disparlure in one application using a small fixed-wing aircraft. The efficacy results were excellent as no adult male moths were captured within the treated block from 1989 through 1991 (male moths were recovered in an associated untreated block). In spite of the favorable efficacy results, the application equipment which intermittently malfunctioned and produced an uneven deposition pattern of flakes across the swath raised concerns for future use. Also, the flakes released only a small percentage of their disparlure content during male moth flight.

In 1990, a replicated study was conducted in Rockbridge County, Virginia, to evaluate three treatments: (1) two applications of flakes in 1990 only, each at a dose of 30.4 g AI per acre, (2) a single application of flakes in 1990 and again every year from 1991 through 1993 at a dose of 30.4 g AI per acre, and (3) untreated. The efficacy results over all years (1990 through 1994) showed that gypsy moth populations were significantly reduced by either type of flake treatment (Leonhardt et al. 1996). The flake application equipment continued to malfunction and, based on anticipated high costs to replace or redesign the equipment, an effort was made to locate another controlled-release formulation that could be applied through conventional booms and nozzles.

In 1990, AgriSense (formerly biosys and now Thermo Trilogy, Columbia, MD) developed a polymeric flowable bead formulation containing disparlure (Decoy GM). Release rate evaluations showed that the bead formulation released disparlure at a faster rate than the plastic laminate flake formulation.

In 1991 through 1994, various trials were conducted using the beads applied in two applications at doses from 6 to 30.4 g AI per acre per application in 1 gal of tank mix per acre per application. Although efficacy results were inconsistent over the various doses, in general results were favorable at doses as low as 6 g AI per acre per application for two applications. A bead formulation containing a greater portion of larger diameter beads was manufactured in an effort to slow the disparlure release rate.

The flakes were used operationally in several States. The operability of the application equipment for the flakes was improved by upgrading the motors for turning the augers and enlarging the holding capacity of the flake hoppers.

Current Disparlure Formulations and Use

The plastic flake formulation Disrupt II is registered by the U.S. EPA and used operationally to manage low density populations of the gypsy moth. The plastic flakes are applied at 30.4 g AI per acre of disparlure for one application using pods mounted on the underside of the aircraft wing. The polymeric bead formulation Decoy GM is not registered by the U.S. EPA, but an application for registration was submitted in February 1995. The beads are applied at 15.2 g AI per acre per application in two applications, using CP or Micronair AU-5000 atomizers with screen cages removed and attached to standard spray booms. Formulation costs are approximately $8 per acre for the flakes and $3 per acre for the beads. The active ingredient which is not included in the cost of formulation costs between $400 - $700 per kg, which equates to $12 - $20 per acre for a 30.4 g AI dose.

The exact biological parameters for the successful use of the mating disruption technique have not been identified although the technique should be used only to manage isolated or area-wide (to reduce the possibility of insect movement into the treated area) low density populations of the European strain. The technique is specific for the gypsy moth and has no known impacts on nontarget organisms.

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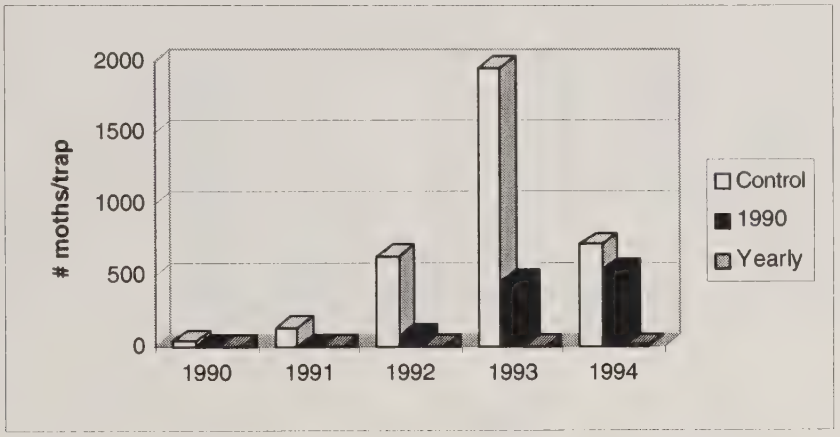
Appendix A

Charts

Chart A. *Efficacy data for woodlots treated yearly (1990-1993) with a single application of Disrupt II (Yearly), woodlots treated with a double application in 1990 only (1990), and untreated woodlots (Control).*

a. Average number of male moths per trap

	1990	1991	1992	1993	1994
Control	33	130	635	1960	716
1990	0.3	0.5	76.9	458	534
Yearly	0	0	0.2	0.6	9



b. Average number of life stages per 100 burlap bands

	1990	1991	1992	1993	1994
Control	5	30	217	709	2697
1990	1	0.8	17	161	1446
Yearly	3	0.2	1.4	32	18

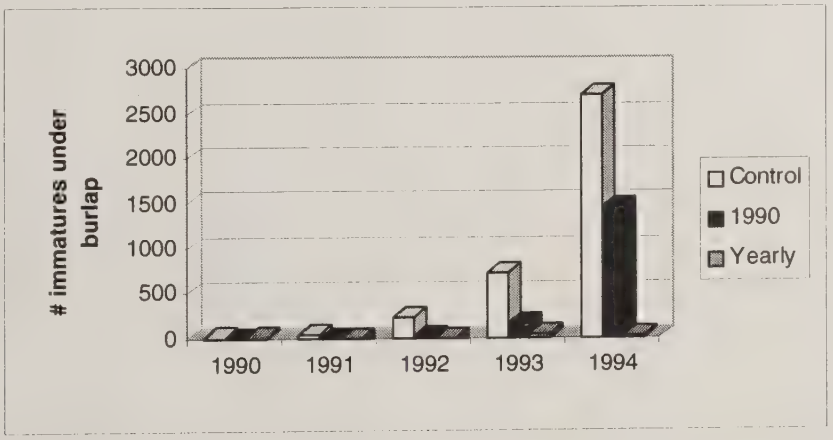
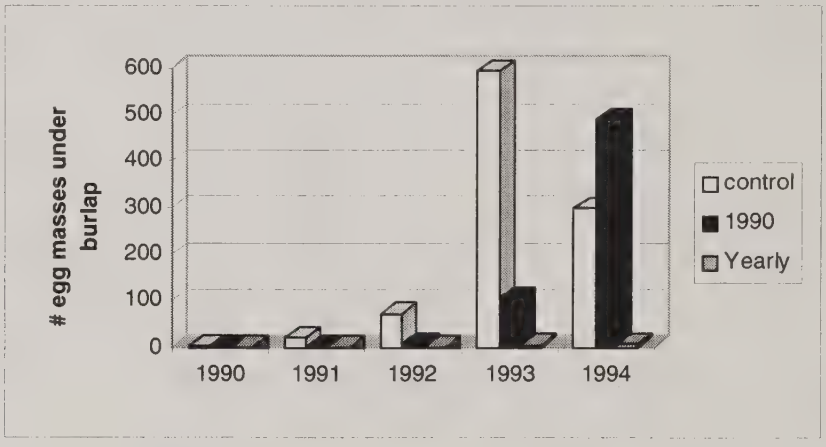


Chart A. *Continued*

c. Average numbers of fertile egg masses per 100 burlap bands

	1990	1991	1992	1993	1994
Control	3.5	21	71	594	299
1990	0	0.3	7	105	490
Yearly	0	0.1	0	4	6



d. Average number of egg masses per hectare from 0.01 ha plots

	1990	1991	1992	1993	1994
Control	10	14	177	3136	2384
1990	0	0.3	9	286	1268
Yearly	2	0.3	0	14	13

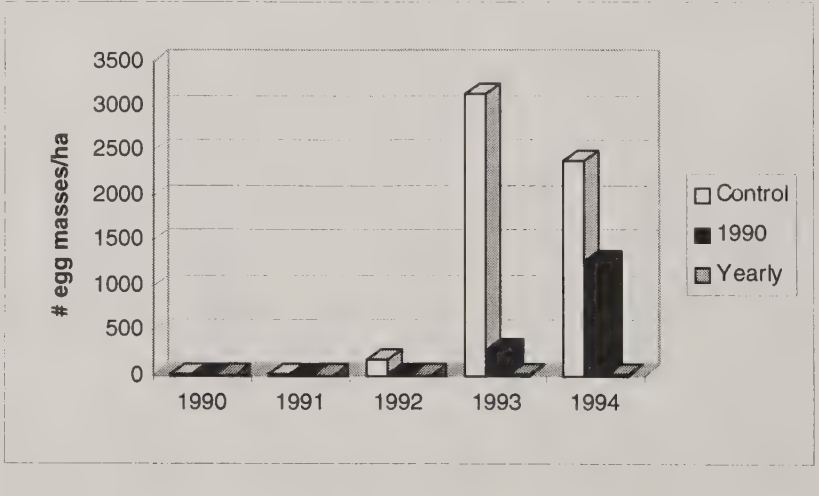


Chart A. *Continued*

e. Percent monitor females mated

	1990	1991	1992	1993
Controls	10.3	2.5	68	53
1990	0	0.2	-	-
Yearly	0	0	0.7	0.1

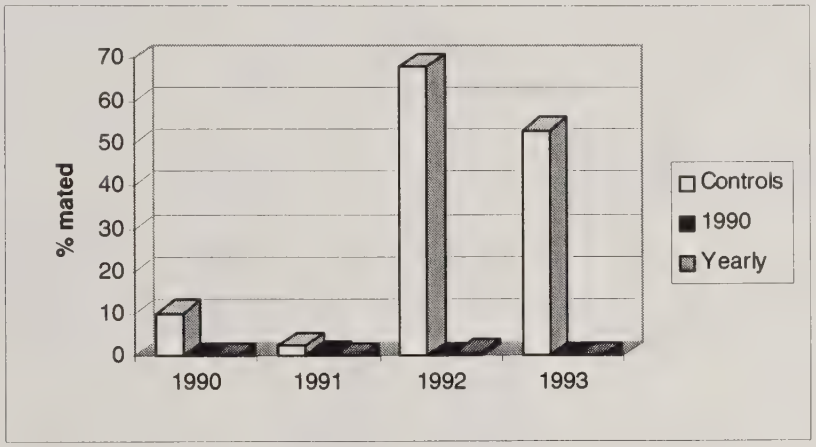
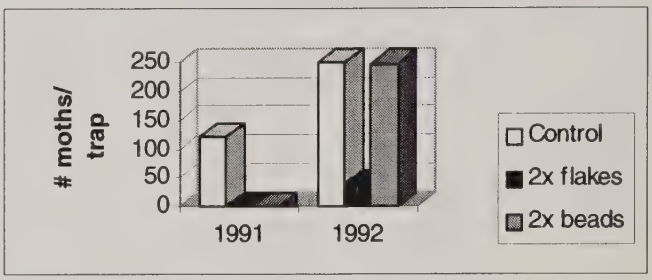


Chart B. *Efficacy data from blocks treated with 2x flakes vs. 2x beads vs untreated in 1991and monitored for treatment effects in 1991 and 1992.*

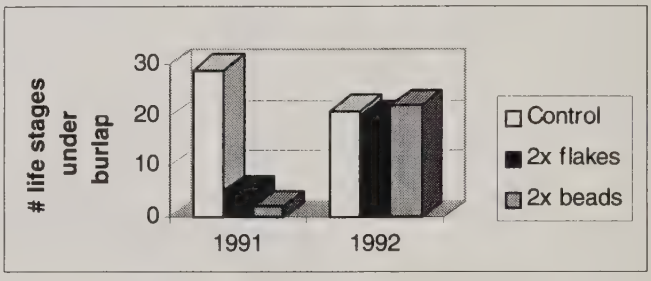
a. Average male moth captures per trap

	1991	1992
Control	121	250
2x flakes	0.1	39
2x beads	0.3	249



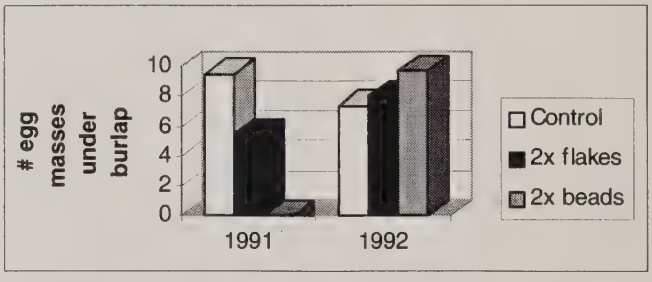
b. Average number of immature life stages per 100 burlap bands

	1991	1992
Control	29	21
2x flakes	5	20
2x beads	2	22



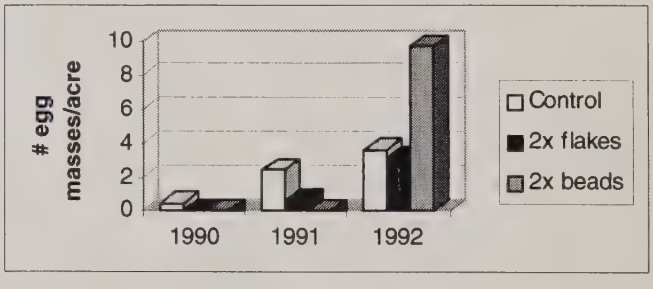
c. Average number of fertile egg masses per 100 burlap bands

	1991	1992
Control	9.5	7.4
2x flakes	5.5	8
2x beads	0	9.7



d. Average number of egg masses per acre, from 1/40th acre plots

	1990	1991	1992
Control	0.5	2.4	3.6
2x flakes	0	0.6	3.1
2x beads	0	0	9.7



e. Percent monitor females mated

	1991	1992
Control	4.2	26.7
2x flakes	0	NA
2x beads	0	NA

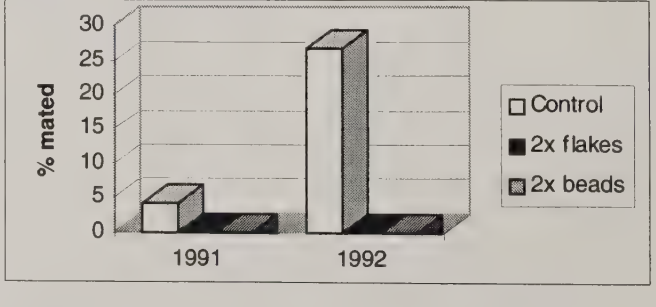


Chart C. *Theoretical emission rate (grams per acre per day) from a double application of beads (6 g AI per acre per application) and a single application of flakes (30.4 g AI per acre)*

Days exposed	Flakes	Beads
0	0.32	0.28
3	0.31	0.25
10	0.3	0.46
15	0.29	0.39
23	0.28	0.26
34	0.25	0.2
43	0.22	0.12

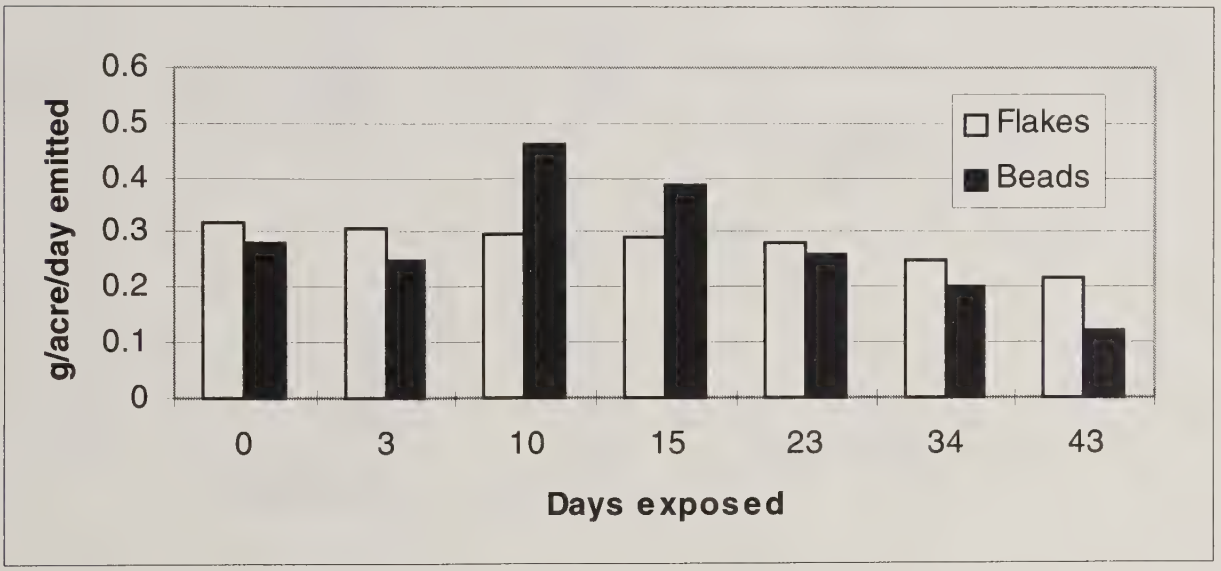
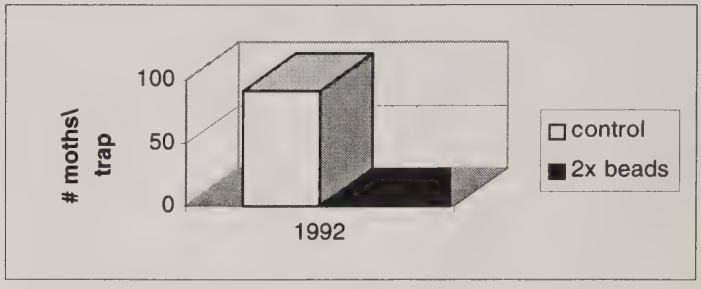


Chart D. *Efficacy data for blocks treated in 1992 with a double application of beads at 6 g AI per acre per application and monitored for treatment effects in 1992 only.*

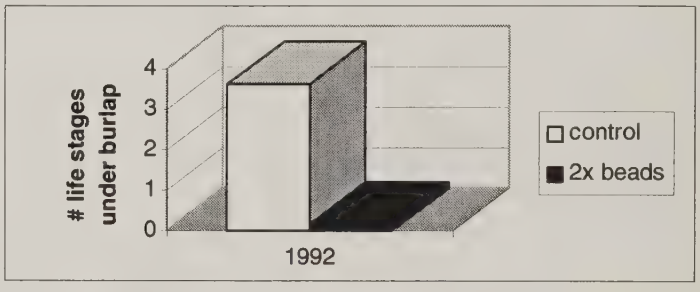
a. Average male moth captures per trap

	1992
Control	91
2x beads	0.4



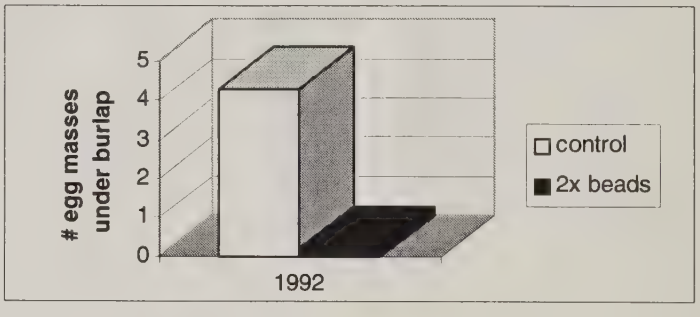
b. Average number of immature life stages per 100 burlap bands

	1992
Control	3.6
2x beads	0.2



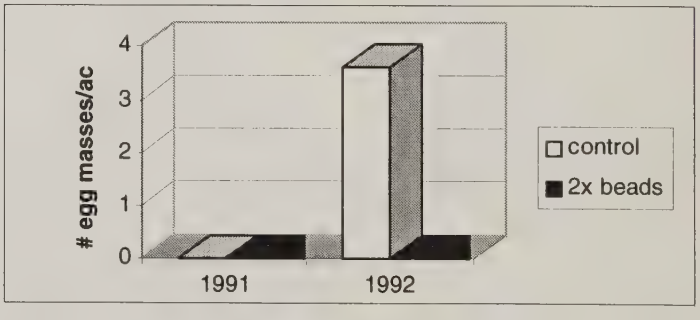
c. Average number of fertile egg masses per 100 burlap bands

	1992
Control	4.3
2x beads	0.2



d. Average number of egg masses per acre, from 1/40th acre plots

	1991	1992
Control	0	3.6
2x beads	0	0



e. Percent monitor females mated

	1992
Control	18.6
2x beads	0.3

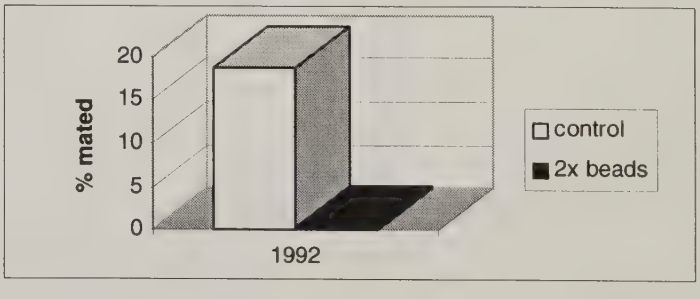
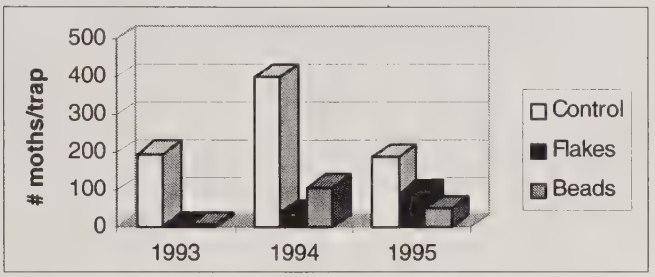


Chart E. *Efficacy data for blocks treated in 1993 with 2 applications of 6 g AI per acre per application beads, a single application of 20 g AI per acre flakes and controls; monitored in 1993-94*

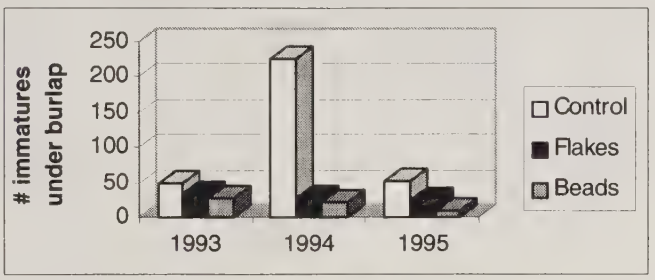
a. Average numbers of male moths per trap

	1993	1994	1995
Control	197	402	188
Flakes	1.3	38	90
Beads	3.4	107	48



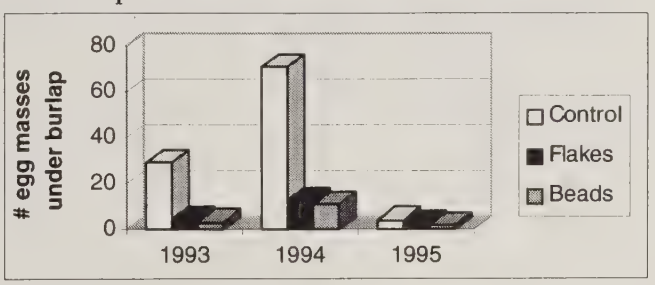
b. Average number of immature life stages per 100 burlap bands

	1993	1994	1995
Control	49.6	226	50.6
Flakes	34.1	27.5	24.9
Beads	27.8	20.8	9.4



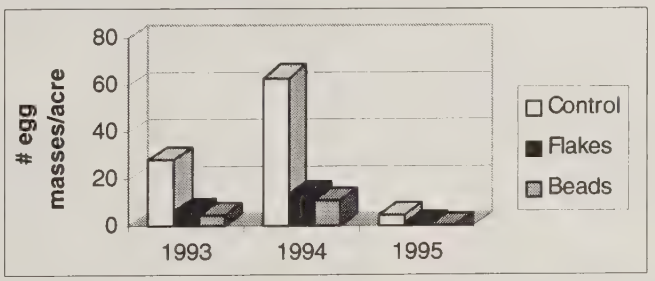
c. Average number of fertile egg masses per 100 burlap bands

	1993	1994	1995
Control	29	72	3.8
Flakes	4.2	12.9	2.4
Beads	3.0	10.8	1.4



d. Average number of egg masses per acre from 1/40th acre plots

	1993	1994	1995
Control	28	63	5
Flakes	6.7	13.9	1.4
Beads	4.4	10.8	0



e. Percent monitor females mated

	1993
Controls	28.4
Flakes	0.2
Beads	0

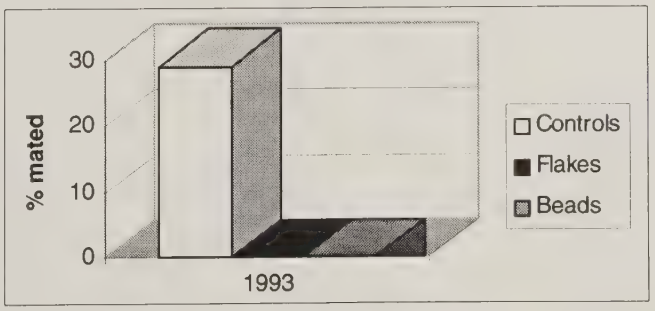
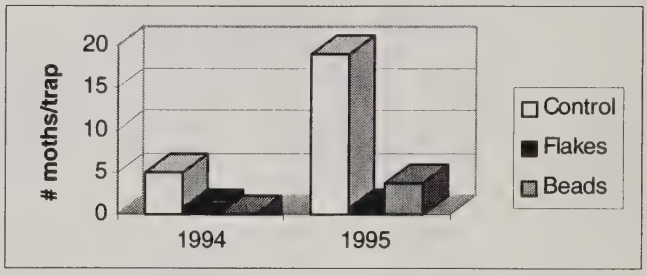


Chart F. *Efficacy data for blocks treated in 1994 with a double application of beads at 15.2 g AI per acre per application, a single application of flakes at 30.4 g AI per acre, and untreated blocks.*

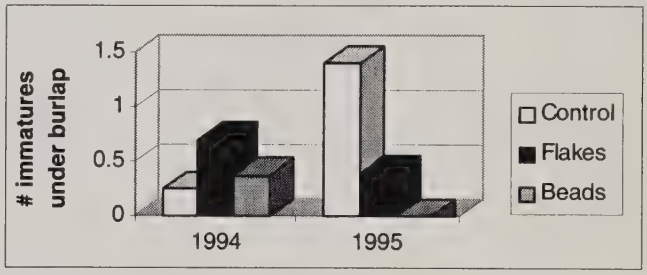
a. Average numbers of males moths per trap

	1994	1995
Control	5	19
Flakes	0.9	0.8
Beads	0	3.7



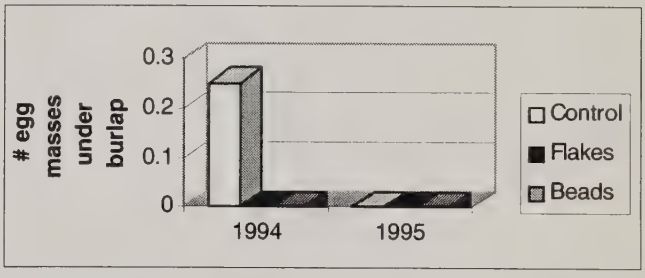
b. Average number of immature life stages per 100 burlap bands

	1994	1995
Control	0.3	1.5
Flakes	0.7	0.4
Beads	0.4	0



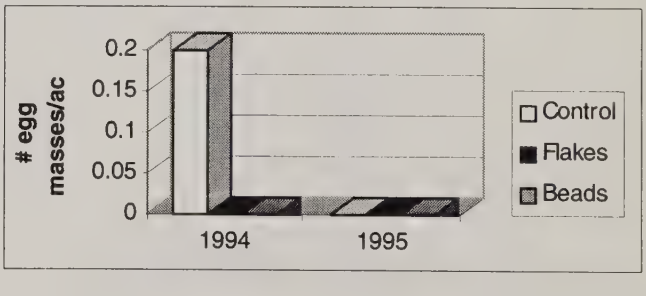
c. Average number of fertile egg masses per 100 burlap bands

	1994	1995
Control	0.3	0
Flakes	0	0
Beads	0	0



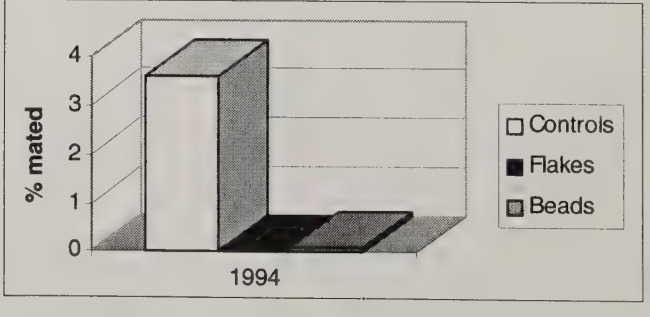
d. Average number of egg masses per acre from 1/40th acre plots

	1994	1995
Control	0.2	0
Flakes	0	0
Beads	0	0



e. Percent monitor females mated

	1994
Controls	3.4
Flakes	0
Beads	0.1



Appendix B

Labels

HERCON DISRUPT II Gypsy Moth is a controlled release pheromone dispenser formulation designed to lower incidence of gypsy moth, *Lymantria dispar*, mating by disrupting normal male orientation to females. This reduction in mating will help suppress the larval (caterpillar) population which causes damage by feeding on the leaves of hardwoods and evergreens.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This Standard contains requirements for the protection of agriculture workers of farms, forest, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification and emergency assistance.

It also contains specific instruction and exceptions pertaining to the statements on this label about Personal Protective Equipment (PPE) and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

Do not enter or allow worker entry into treated areas during restricted entry interval (rei) of 4 hours. PPE required for early entry to treated areas that is permitted under Worker Protection Standard and that involves contact with anything that has been treated such as plants, soil or water, is: coveralls, Waterproof gloves and shoes and socks.

Using air or ground equipment apply, at least two weeks before adult gypsy moth emergence, 30-40 grams active ingredient per application per acre. Apply a second application if adult gypsy moth emergence is extended or delayed. An inert sticker material should be used with **DISRUPT II Gypsy Moth** to hold flakes on treated foliage or plant parts. The Hercon applicator equipment is specifically designed to mix the proper amount of **DISRUPT II Gypsy Moth** flakes and the inert sticker at the time of application.

Use in such areas as forests; residential, municipal and shade tree areas; recreational areas such as campgrounds, golf courses, parks and parkways; ornamental, shade trees and forest nurseries; forest plantings; shelter belts; and rights of way and other easements.

Application must be done by or under the supervision of a qualified person to insure proper rate and method of application.

HERCON®

DISRUPT® II

Gypsy Moth

POPULATION SUPPRESSANT
MATING DISRUPTANT

HELPS PREVENT FUTURE LEAF DAMAGE
REDUCES MOTH MATING

ACTIVE INGREDIENT:
[Z] -7,8-epoxy-2-methyloctadecane 17.9%
INERT INGREDIENTS: 82.1%
TOTAL: 100.0%

NET WEIGHT: kg [lb.]*

KEEP OUT OF REACH OF CHILDREN

CAUTION

Read Directions and Precautionary Statements Before Use

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

Precautionary Statements: Keep out of reach of children. Do not open protective cover until ready to use.

Personal Protective Equipment (PPE): Applicators and other handlers must wear long-sleeved shirt and long pants, waterproof gloves and shoes plus socks, Follow manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

User Safety Recommendations: Users should wash hands before eating, drinking, chewing gum, using tobacco products or using the toilet.

HAZARDS TO THE ENVIRONMENT

Keep out of lakes, streams, ponds. Do not contaminate water by cleaning of equipment or disposal of wastes.

STORAGE AND DISPOSAL

Storage: Store in sealed containers in cool, dry place. Keep partially used containers tightly sealed.

Pesticide Disposal: Do not contaminate water, foods or feed by storage or disposal. Pen dumping is prohibited. Wastes resulting from use of this product may be disposed of on site or at an approved waste disposal facility.

Container Disposal: Completely empty bag into application equipment. Wrap bag and place in trash collection.

Note: Use of pheromones and limiting the use of conventional insecticides will help maintain the population of beneficial parasites and predators. This can assist in biological control of gypsy moth and other pests, and therefore complement pest management. **DISRUPT II Gypsy Moth** can be used as a pest management tool by lowering the incidence of gypsy moth mating in low level populations. In areas of heavy infestation, **DISRUPT II Gypsy Moth** is recommended as a follow-up to larvicidal treatments as part of an Integrated Pest Management program.

*10 kg [22 lb.] of "flakes" will be sufficient to treat 61.1 acres at 30.4 g A.I./acre

EPA Reg. No. 8730-55

EPA Est. No. 8730-PA-01

Warranty and Limitation of Damages: Seller warrants that this product complies with the specifications expressed on the label and is reasonably fit for the purpose stated when used in accordance with directions under normal conditions of use and Buyer assumes the risk of any use contrary to such directions. Seller makes no other express or implied warranty, including any other express or implied warranty of fitness or of merchantability, and no agent of Seller is authorized to do so except in writing with a specific reference to this warranty. In no event shall Seller's liability for any breach of warranty exceed the purchase price of the material as to which a claim is made.

HERCON Environmental

Made in the USA by
HERCON ENVIRONMENTAL CORPORATION
Aberdeen Road, Emigsville, PA 17318-0467

PRECAUTIONARY STATEMENT

HAZARD TO HUMANS AND DOMESTIC ANIMALS

CAUTION

Causes skin irritation. Do not get in eyes, on skin, or on clothing. Harmful if swallowed, inhaled, or absorbed through the skin. Avoid breathing vapors. Wash thoroughly with soap and water after handling.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Applicators and other handlers must wear:

- Long-sleeved shirt and long pants.
- Water-proof gloves.
- Shoes plus socks.

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

ENVIRONMENTAL HAZARDS

Keep out of lakes, streams and ponds. Do not contaminate water by cleaning of equipment or disposal of waste.

STATEMENT OF PRACTICAL TREATMENT

For eye contact, flush with running water for at least 15 minutes.

For skin contact, wash with soap and water. If irritation develops, consult a physician.

For ingestion, drink 2 glasses of water and induce vomiting. Consult a physician.

Registered By:

biosys

1057 East Meadow Circle
Palo Alto, CA 94303

AGRISENSE®

DECOY™ GM BEADS

ACTIVE INGREDIENTS:
2-Methyl-Z-7, 8-Epoxyoctadecane 34.04%
(Racemic Disparlure)
INERT INGREDIENTS: 65.96%

KEEP OUT OF REACH OF CHILDREN

CAUTION

Read Directions and Precautionary Statements Before Use

Net Content: 1.94 lbs (0.894 kg)

Lot # _____

EPA Reg. No. EPA Est. No.

894 GRAM PACKET

DIRECTIONS FOR USE

(GENERAL CLASSIFICATION)

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling. Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or tribe, consult the agency responsible for pesticide regulation.

See Supplemental Labeling for Specific Use Directions.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. Refer to supplemental labeling under "Agricultural Use Requirements" in the Directions for Use section of Supplemental Labeling for information about this standard.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

STORAGE: Store in a cool, well ventilated area. Protect from ignition sources. Avoid contact with high temperatures, acids, bases. Store sealed to prevent loss of product.

PRODUCT DISPOSAL: This product has been packaged for ease of use and minimization of waste. Unsealed excess product or wastes resulting from the use of this product, may be used on site, or must be disposed of in compliance with applicable Federal, State or Local regulations.

CONTAINER DISPOSAL: Completely empty bag into application equipment. Then, dispose of empty bag in a sanitary landfill or by incineration, or, if allowed by State and Local authorities, by burning. If burned, stay out of smoke.

Produced For:

AGRISENSE
A Division of **biosys**
1057 East Meadow Circle
Palo Alto, CA 94303

WARNING: Keep Out of Reach of Children

NET CONTENTS: US GALLONS (Litres)

Appendix C

Material Safety Data Sheets

MATERIAL SAFETY DATA SHEET

SECTION I. MANUFACTURER

HERCON ENVIRONMENTAL
P.O. BOX 467 ABERDEEN RD.
EMIGSVILLE, PA 17318

For information or in an emergency,
call (717)764-1191

SECTION II.

HAZARDOUS MATERIAL
IDENTIFICATION SYSTEM

HEALTH = 1
FLAMMABILITY = 0
REACTIVITY = 0

****

SECTION III. PRODUCT INFORMATION

PRODUCT NAME: *Hercon Disrupt II Gypsy Moth Mating Disruptant Pheromone/Attractant Dispenser for Use as a Mating Disruptant, (Lymantria dispar)*

COMMON NAME OF ACTIVE INGREDIENT: *R*acemic disparlure

CHEMICAL NAME:
(7R,8S)-cis-7,8-epoxy-2-methyloctadecane

C.A.S. NUMBERS: *35898-62-5*
FORMULA: *C19H380,*
PRODUCT FORM: *Laminated polymeric solid dispenser for aerial applications*

****

SECTION IV. PHYSICAL PROPERTIES

BULK DENSITY: NA
MELTING POINT 300 ^{O}F: NA
FREEZING POINT: NA
PERCENT VOLATILE MATERIAL: Less than 1%
ODOR DESCRIPTION: Mild
VAPOR PRESSURE (20^{O}C mm HG): Not determined

SPECIFIC GRAVITY/25^{O}C: NA
BOILING POINT: NA
VISCOSITY: NA
pH: NA
VAPOR DENSITY (AIR=1): NA
SOLUBILITY IN WATER: Insoluble

****

SECTION V. PRODUCT HAZARD INFORMATION

PERCENT ACTIVE INGREDIENT IN PRODUCT: 17.9%
OCCUPATIONAL EXPOSURE LIMITS: Not established

HEALTH/TOXICITY INFORMATION: Toxicological properties of the active ingredient have been investigated: Oral LD50 (rat) > 34,600 mg/kg, Dermal LD50 (rat)>2,025 mg/kg. Use appropriate procedures to prevent direct contact with skin or eyes and prevent inhalation. No. significant toxicity expected.

EFFECTS OF OVEREXPOSURE: None reported

.....continued

EMERGENCY AND FIRST AID PROCEDURES:

EYES: *Flush with water for at least 15 minutes.*
SKIN: *Wash with soap and water. If irritation develops, seek medical attention.*
INHALATION: *Remove from exposure. If breathing is labored, provide oxygen.*
INGESTION: *If ingested, drink plenty of water. Get medical attention.*

SYMPTOMS OF EXPOSURE: *May cause skin or eye irritation.*

****

SECTION VI. FIRE HAZARD INFORMATION

FLASH POINT: NA FLAMMABLE LIMITS IN AIR: NA
EXTINGUISHING MEDIA: Carbon dioxide, foam
SPECIAL FIRE FIGHTING PROCEDURES: If involved in fire, use air-supplied equipment. Do not inhale fumes.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None

****

SECTION VII. REACTIVITY INFORMATION

PRODUCT STABILITY: Unstable _____ Stable X_____

HAZARDOUS POLYMERIZATION: May Occur _____ May Not OccurX_____

CONDITIONS TO AVOID: None specified MATERIAL TO AVOID: strong oxidizing agents.

HAZARDOUS DECOMPOSITION PRODUCTS: On combustion, the polymeric dispenser may produce, CO, CO_2 HCL and CL_2

****

SECTION VIII. SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR5 SPILLED: Place unpouched strips in tightly sealed containers, Keep out of water sources and sewers.

WASTE DISPOSAL METHOD: Incinerate or otherwise manage at RCRA permitted waste management facility. Do not reuse empty containers. Check state and local authorities for other options.

****

SECTION IX. PERSONAL PROTECTION INFORMATION

RESPIRATORY PROTECTION: Usually none require.
EYE PROTECTION: Usually none required.
VENTILATION: Good general ventilation.
PROTECTIVE GLOVES: None required but vinyl latex or rubber gloves recommended for continuous handling.
OTHER PROTECTIVE EQUIPMENT: None under normal usage.

NOTE: Personal protection information described above is based upon general information as to normal uses and conditions. Where special or unusual uses or conditions exist, it is suggested that the expert assistance of an industrial hygienist or other qualified professional be sought.

****

SECTION X. HANDLING AND STORAGE PRECAUTIONS

GENERAL PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Store in sealed pouches in a cool dry area, away from excessive heat and open flame. To maintain product integrity protect from high temperatures. Keep container sealed. Launder contaminated clothing before use. Wear protective equipment described above if exposure conditions warrant. Do not allow to contaminate water sources, food or feed.
SPECIAL PRECAUTIONARY CONDITIONS: None

****

SECTION XI. TRANSPORTATION DATA

DOT LABEL: Non-hazardous material.

****

SECTION XII. DISCLAIMER

It is the user's responsibility to determine the suitability of this information for the adoption of necessary safety precautions. We reserve the right to revise material safety data sheets periodically as new merchantability, fitness for a particular purpose of any other nature are made hereunder with respect to the information contained herein or the chemical to which the information refers. Hercon Environmental assumes no responsibility for any damages, losses, injuries or consequential damages which may result from the use or misuse of this product and the recipient assumes all such risks.

MSDS Number 100306 DATE ISSUED: 24 Mar. 1992(AQ)

By: Priscilla MacLean DATE REVISED:7 Mar. 1995

TITLE: Product Development Manager

AGRISENSE™

Material Safety Data Sheet

PHEROMONES

Disparlure Beads

(See Attached List for Specific Products)

AGRISENSE
A joint venture between subsidiaries of
Phillips Petroleum Company and Dow
Corning Corporation
15D2 Phillips Building
Bartlesville, Oklahoma 74004

PHONE NUMBERS
Emergency:
Business Hours (918) 661-3865
After Hours (918) 661-8118
General MSDS Information:
(918) 661-8327

A. Product Identification

Synonyms: Not Established
Chemical Name: Various
Chemical Family: Various
Chemical Formula: Various
CAS Reg. No.: Various
Product No.: Not Established

Product and/or Components Entered on EPA's TSCA Inventory: YES

B. Hazardous Components

Ingredients	CAS Number	% By Wt.	OSHA PEL	ACGIH TLV

This product does not meet the definition of a hazardous chemical given in 29 CFR Part 1910.1200 (OSHA). Information on this form is furnished as a customer service.

C. Personal Protection Information

Ventilation: Use adequate ventilation.

Respiratory Protection: Not generally required.

Eye Protection: Use safety glasses with side shields.

Skin Protection: No special garments required. Avoid unnecessary skin contamination with material. Use impervious gloves.

NOTE: Personal protection information shown in Section C is based upon general information as to normal uses and conditions. Where special or unusual uses or conditions exist, it is suggested that the expert assistance of an industrial hygienist or other qualified professional be sought.

D. Handling and Storage Precautions

Avoid inhalation of vapors or mists. Avoid contact with skin, eyes or clothing. Wear protective equipment described in Section C if exposure conditions warrant. Keep containers closed. Wash hands after handling. Provide means of controlling leaks and spills. Launder contaminated clothing before reuse. Refer to CFR Title 40, Part 165.10 for storage requirements for pesticides and pesticide containers. Do not allow product to contaminated water sources, food or feed.

E. Reactivity Data

Stability:	Stable
Conditions to Avoid:	Not Applicable
Incompatibility (Materials to Avoid):	Oxygen and strong oxidizing agents
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid:	Not Applicable
Hazardous Decomposition Products:	Carbon oxides formed when burned.

F. Health Hazard Data

Recommended Exposure Limits:

None established.

Acute Effects of Overexposure:

Eye:	May be moderately irritating.
Skin:	May be moderately irritating.
Inhalation:	No known applicable information.
Ingestion:	No known applicable information.

Subchronic and Chronic Effects of Overexposure:

No known applicable information.

Other Health Effects:

No known applicable information.

Health Hazard Categories:

	Animal	Human		Animal	Human
Known Carcinogen	___	___	Toxic	___	___
Suspect Carcinogen	___	___	Corrosive	___	___
Mutagen	___	___	Irritant	___	___
Teratogen	___	___	Target Organ Toxin	___	___
Allergic Sensitizer	___	___	Specify - No known applicable information.		
Highly Toxic	___	___			

First Aid and Emergency Procedures:

Eye: Flush eyes with water for at least 15 minutes. If irritation develops, seek medical attention.

Skin: Wash with soap and water. If irritation develops, seek medical attention.

Inhalation: Remove from exposure. If illness develops, seek medical attention.

Ingestion: Induce vomiting. If illness develops, seek medical attention.

G. Physical Data

Appearance:	Various colored liquids or waxy solid
Odor:	Mild
Boiling Point:	Not Established
Vapor Pressure:	Not Established
Vapor Density (Air = 1):	Not Established
Solubility in Water:	Not Established
Specific Gravity (H2O = 1):	Not Established
Percent Volatile by Volume:	Not Established
Evaporation Rate (Ethyl Ether = 1):	<1
Viscosity:	Not Established

H. Fire and Explosion Data

Flash Point (Method Used):	Not Established (Estimated to be above 200F)
Flammable Limits (% by Volume in Air):	LEL - Not Established UEL - Not Established
Fire Extinguishing Media:	Dry chemical, foam, carbon dioxide (CO2).
Special Fire Fighting Procedures:	Evacuate area of all unnecessary personnel.
Fire and Explosion Hazards:	Carbon oxides formed when burned.

I. Spill, Leak and Disposal Procedures

Precautions Required if Material is Released or Spilled:
Contain spill. Protect from ignition. Keep out of water sources and sewers. Absorb in a dry, inert material (sand, clay, sawdust, etc.)

Waste Disposal (Insure Conformity with all Applicable Disposal Regulations):
Incinerate or otherwise manage at a RCRA permitted waste management facility. Triple rinse containers, then recycle, recondition or puncture and dispose of in a sanitary landfill. Check state and local authorities for other options.

J. DOT Transportation

Shipping Name:	Not Applicable
Hazard Class:	Not Applicable
ID Number:	Not Applicable
Marking:	Not Applicable
Label:	Not Applicable
Placard:	Not Applicable
Hazardous Substance/RQ:	Not Applicable
Shipping Description:	Not Applicable
Packaging References:	Not Applicable

K. RCRA Classification - Unadulterated Product as a Waste

Not Applicable

L. Protection Required for Work on Contaminated Equipment

Wear protective equipment and/or garments described in Section C if exposure conditions warrant. Contact immediate supervisor for specific instructions before work is initiated.

M. Hazard Classification

___ This product meets the following hazard definition(s) as defined by the Occupational Safety and Health Hazard Communication Standard (29 CFR Section 1910.1200):

___ Combustible Liquid	___ Flammable Aerosol	___ Oxidizer
___ Compressed Gas	___ Explosive	___ Pyrophoric
___ Flammable Gas	___ Health Hazard (Section F)	___ Unstable
___ Flammable Liquid	___ Organic Peroxide	___ Water Reactive
___ Flammable Solid		

_X_ Based on information presently available, this product does not meet any of the hazard definitions of 29 CFR Section 1910.1200.

N. Additional Comments

This pheromone product is provided for use ONLY in:

Research and development to determine whether the product has pest control value.

Pheromone traps where it is the sole active ingreditent.

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

As of the preparation date, this product did not contain a chemical or chemicals subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

MONSANTO PRODUCT NAME
GELVA® MULTIPOLYMER RESIN EMULSION 2333

MONSANTO COMPANY
800 N. LINDBERGH BLVD.
ST. LOUIS, MO 63167
EMERGENCY PHONE NO.
(CALL COLLECT)
314-694-1000

PRODUCT IDENTIFICATION

Chemical Name: Acrylic multipolymer emulsion
Components: 2-Propenoic acid, polymer with ethenyl acetate and 2-ethylhexyl 2-propenoate, CAS No. 26634-78-6
Water, CAS No. 7732-18-5
Poly(oxy-1,2-ethanediyl)α-sulfo-ω-(nonyl-phenoxy)-, ammonium salt, CAS No. 9051-57-4
DOT Proper Shipping Name: Not Applicable
DOT Hazard Class/I.D. No.: Not Applicable
DOT Label: Not Applicable
U.S. Surface Freight Classification: Plastics, synthetic, N.O.I., liquid
Reportable Quantity (RQ) Under DOT (49 CFR) and CERCLA Regulations: Not Applicable

SARA Hazard Notification

Hazard Categories under criteria of SARA Title III rules (40 CFR Part 370): Not Applicable

Section 313 Toxic Chemical(s): Not Applicable

Hazardous Chemical(s) Under OSHA Hazard Communication Standard: Not Applicable

PRECAUTIONARY MEASURES AND FIRST AID

HANDLE IN ACCORDANCE WITH GOOD INDUSTRIAL HYGIENE AND SAFETY PRACTICES. THESE PRACTICES INCLUDE AVOIDING UNNECESSARY EXPOSURE AND REMOVAL OF THE MATERIAL FROM EYES, SKIN AND CLOTHING.

OCCUPATIONAL CONTROL PROCEDURES

Eye Protection: Although GELVA® multipolymer resin emulsion 2333 does not cause significant eye irritation or eye toxicity requiring special protection, good industrial practice should be used to avoid eye contact.

Skin Protection: GELVA multipolymer resin emulsion 2333 may cause irritation following repeated or prolonged contact. Minimize skin contamination by following good industrial practice. Wearing of protective gloves is recommended. Wash hands and contaminated skin after handling.

Respiratory Protection: Avoid breathing vapor and/or mist. Use NIOSH/MSHA approved respiratory protection equipment when airborne exposure is excessive. Consult respirator manufacturer to determine appropriate type equipment for given application. Observe respirator use limitations specified by NIOSH/MSHA or the manufacturer. Respirator protection programs must comply with 29 CFR 1910.134.

OCCUPATIONAL CONTROL PROCEDURES (continued)

Ventilation: Provide natural or mechanical ventilation to minimize exposure. If practical, use local mechanical exhaust ventilation at sources of air contamination such as open process equipment.

Airborne Exposure Limits:

Product: Acrylic multipolymer emulsion

OSHA PEL: None established
ACGIH TLV: None established

FIRE PROTECTION INFORMATION

Flash Point: >200°F Method: Pensky-Martens, Closed Cup

Extinguishing Media: Water spray, foam, carbon dioxide, dry chemical or any Class B extinguishing agent. Use water spray to cool containers.

Special Firefighting Procedures: Firefighters or others who may be exposed to products of combustion (see "Hazardous Decomposition Products", below) should wear full protective clothing including self-contained breathing apparatus. Equipment should be thoroughly decontaminated after use.

Unusual Fire and Explosion Hazards: None known.

REACTIVITY DATA

Materials to Avoid: None.

Hazardous Decomposition Products: Carbon monoxide, carbon dioxide.

Hazardous Polymerization: Does not occur.

HEALTH EFFECTS SUMMARY

The following information summarizes human experience and results of scientific investigations reviewed by health professionals for hazard evaluation of GELVA multipolymer resin emulsion 2333 and development of Precautionary Measures and Occupational Control Procedures recommended in this document.

Effects of Exposure

Dermal contact is expected to be the primary route of occupational exposure to GELVA multipolymer resin emulsion 2333. Occupational exposure to this material has not been reported to cause significant adverse human health effects. On the basis of available information, exposure to GELVA multipolymer resin emulsion 2333 is not expected to produce any significant adverse human health effects when recommended safety precautions are followed.

HEALTH EFFECTS SUMMARY (continued)

Toxicological Data

Data from laboratory studies conducted by Monsanto are discussed below:

Single exposure (acute) studies indicate:

Oral - Practically Nontoxic (Rat LD50 - >5,000 mg/kg)
Dermal - Practically Nontoxic (Rabbit LD50 - >5,000 mg/kg)
Eye Irritation - Practically Nonirritating (Rabbit)
Skin Irritation - Practically Nonirritating (Rabbit, 4-hr and 24-hr exposure)

No genetic effects were observed in standard tests with a similar GELVA multipolymer resin emulsion using bacterial and animal cells.

GELVA multipolymer resin emulsion 2333 was tested for potential to produce allergic skin reaction in controlled skin contact studies in human volunteers. This material demonstrated a potential for cumulative irritation, but primary irritation and allergic skin reactions were not observed.

PHYSICAL DATA

Appearance: White viscous liquid
Odor: Slightly acrid
Dispersibility: 100% in water
Boiling Point: 212°F
Density: 8.5 lbs/gal
Specific Gravity @25°C: 1.01
Total Solids: 52.0 - 55.5%
Brookfield Viscosity: 300 - 700 cps at 25°C
pH: 4.5 - 5.5

NOTE: These physical data are typical values based on material tested but may vary from sample to sample. Typical values should not be construed as a guaranteed analysis of any specific lot or as specifications for the product.

SPILL, LEAK & DISPOSAL INFORMATION

Waste Disposal: GELVA multipolymer resin emulsion 2333 is not a "hazardous waste" as that term is defined in 40 CFR 261, "Identification and Listing of Hazardous Waste". May be disposed of in a sanitary landfill licensed to receive non-hazardous waste. Disposal should be in accordance with all applicable local, state, and federal laws and regulations. Consult your attorney or appropriate regulatory officials for information on such disposal.

Spill or Leakage Procedures: In case of spill or leak, apply sawdust or sweeping compound to soak up. For large spills, use bailing methods into containers. May be flushed to sewer or settling ponds if local regulations permit.

ENVIRONMENTAL EFFECTS

96-hr LC50, Rainbow trout: >1,000 mg/l, Practically Nontoxic
96-hr LC50, Bluegill sunfish: >1,000 mg/l, Practically Nontoxic
48-hr LC50, Daphnia magna: >1,000 mg/l, Practically Nontoxic

ADDITIONAL COMMENTS

GELVA multipolymer resin emulsion 2333 should not be exposed to temperature extremes.

DATE: 4/11/90 SUPERSEDES: 3/20/90

MSDS NUMBER S00010621

FOR ADDITIONAL NON-EMERGENCY INFORMATION, CONTACT:

Manager, Product Safety
Resins Division
Monsanto Chemical Company
A unit of Monsanto Company
314-694-1000

NALCO

MATERIAL SAFETY DATA SHEET

PRODUCT NALQUATIC HERBICIDE ADJUVANT

Emergency Telephone Number
Medical (708) 920-1510 (24 hours)

SECTION 1 PRODUCT IDENTIFICATION

TRADE NAME: NALQUATIC HERBICIDE ADJUVANT
DESCRIPTION: A polyacrylate in a hydrocarbon solvent and water

NFPA 704M/HMIS RATING: 1/1 HEALTH 1/1 FLAMMABILITY 0/0 REACTIVITY 0 OTHER
0=Insignificant 1=Slight 2=Moderate 3=High 4=Extreme

SECTION 2 HAZARDOUS INGREDIENTS

Our hazard evaluation has identified the following chemical ingredients as hazardous under OSHA's Hazard Communication Rule, 29 CFR 1910.1200. Consult Section 14 for the nature of the hazards.

INGREDIENT(S)	CAS #	APPROX.%
Paraffinic/naphthenic solvent	64742-47-8	20-40
Ethoxylated nonylphenol	9016-45-9	1-10

SECTION 3 PRECAUTIONARY LABEL INFORMATION

CAUTION: May cause irritation to skin and eyes. Avoid contact with skin, eyes, and clothing. Avoid prolonged or repeated breathing of vapor. Use with adequate ventilation. Do not take internally.

Empty containers may contain residual product. Do not reuse container unless properly reconditioned.

SECTION 4 FIRST AID INFORMATION

EYES: Immediately flush for at least 15 minutes while holding eyelids open. Call a physician at once.
SKIN: Wash thoroughly with soap and rinse with water. Call a physician.
INGESTION: Do not induce vomiting. Give water. Call a physician.

NOTE TO PHYSICIAN: No specific antidote is known. Based on the individual reactions of the patient, the physician's judgment should be used to control symptoms and clinical condition.

CAUTION: If unconscious, having trouble breathing or in convulsions, do not induce vomiting or give water.

SECTION 5 HEALTH EFFECTS INFORMATION

PRIMARY ROUTE(S) OF EXPOSURE: Eye, Skin

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AREA 708-305-1000

SECTION 5 HEALTH EFFECTS INFORMATION (CONTINUED)

EYE CONTACT: Can cause moderate irritation.
SKIN CONTACT: Can cause moderate irritation.

SYMPTOMS OF EXPOSURE:
ACUTE: Ethoxylated nonylphenol is an eye irritant.
Paraffinic/naphthenic hydrocarbon solvent is a skin irritant

CHRONIC: Paraffinic hydrocarbon solvent can dry the skin, cause defatting and lead to irritation or dermatitis with prolonged or repeated skin contact.

AGGRAVATION OF EXISTING CONDITIONS: A review of available data does not identify any worsening of existing conditions.

SECTION 6 TOXICOLOGY INFORMATION

ACUTE TOXICITY STUDIES: Acute toxicity studies have not been conducted on this product, but toxicity studies of the ingredient(s) in Section 2 have been reviewed. The results are shown below.

ACUTE ORAL TOXICITY (ALBINO RATS):
Ethoxylated nonylphenol LD50 = 3,000 mg/kg
Paraffinic/Naphthenic solvent LD50 = 40,000 mg/kg

ACUTE DERMAL TOXICITY (ALBINO RABBITS):
Ethoxylated nonylphenol LD50 = Greater than 3,000 mg/kg
Paraffinic/Naphthenic solvent LD50 = 2,000 - 4,000 mg/kg

PRIMARY SKIN IRRITATION TEST (ALBINO RABBITS):
SKIN IRRITATION INDEX DRAIZE RATING:
2.4/8.0 Ethoxylated nonylphenol
5.2/8.0 Paraffinic/naphthenic solvent

PRIMARY EYE IRRITATION TEST (ALBINO RABBITS):
EYE IRRITATION INDEX DRAIZE RATING:
35.5/110.0 Ethoxylated octylphenol
5/110.0 Paraffinic/naphthenic solvent

SECTION 7 PHYSICAL AND CHEMICAL PROPERTIES

COLOR: Cream	FORM: Liquid	ODOR: Slight hydrocarbon	
SOLUBILITY IN WATER:	Completely		
SPECIFIC GRAVITY:	1.1 @ 72 Degrees F		ASTM D-1298
BOILING POINT:	210 Degrees F @ 760 mm Hg		ASTM D-86

SECTION 7 PHYSICAL AND CHEMICAL PROPERTIES (CONTINUED)

FLASH POINT: Greater than 210 Degrees F (PMCC) ASTM D-93

NOTE: These physical properties are typical values for this product.

SECTION 8 FIRE AND EXPLOSION INFORMATION

FLASH POINT: Greater than 210 Degrees F (PMCC) ASTM D-93

EXTINGUISHING MEDIA: Based on the NFPA guide, use dry chemical, alcohol foam, carbon dioxide or other extinguishing agent suitable for Class B fires. Use water to cool containers exposed to fire. For large fires, use water spray or fog, thoroughly drenching the burning material.

UNUSUAL FIRE AND EXPLOSION HAZARD: May evolve NOx under fire conditions.

SECTION 9 REACTIVITY INFORMATION

INCOMPATIBILITY: Avoid water contamination which may cause gelling.

Avoid contact with strong oxidizers (eg. chlorine, peroxides, chromates, nitric acid, perchlorates, concentrated oxygen, permanganates) which can generate heat, fires, explosions and the release of toxic fumes.

STORAGE: In-plant storage limit one year.

FEEDING EQUIPMENT: Recommend carbon steel storage tanks.

THERMAL DECOMPOSITION PRODUCTS: In the event of combustion CO, CO2, NOx may be formed. Do not breathe smoke or fumes. Wear suitable protective equipment.

SECTION 10 PERSONAL PROTECTION EQUIPMENT

RESPIRATORY PROTECTION: Respiratory protection is not normally needed since the volatility and toxicity are low. If significant vapors, mists or aerosols are generated, wear a NIOSH approved or equivalent respirator, (ANSI Z 88.2, 1980 for requirements and selection).

For large spills, entry into large tanks, vessels or enclosed small spaces with inadequate ventilation, a pressure-demand, self-contained breathing apparatus is recommended.

VENTILATION: General ventilation is recommended.

PROTECTIVE EQUIPMENT: Use impermeable gloves and chemical splash

SECTION 10 PERSONAL PROTECTION EQUIPMENT (CONTINUED)

goggles (ANSI Z 87.1 requirements and selection of gloves, goggles, shoes, etc.) when attaching feeding equipment or doing maintenance.

If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse.

SECTION 11 SPILL AND DISPOSAL INFORMATION

IN CASE OF TRANSPORTATION ACCIDENTS, CALL THE FOLLOWING 24-HOUR TELEPHONE NUMBER (708-920-1510)

SPILL CONTROL AND RECOVERY:

Small liquid spills: Contain with absorbent material, such as clay, soil or any commercially available absorbent. Shovel reclaimed liquid and absorbent into recovery or salvage drums for disposal. Refer to CERCLA in Section 14.

Large liquid spills: Dike to prevent further movement and reclaim into recovery or salvage drums or tank truck for disposal. Refer to CERCLA in Section 14.

DISPOSAL: If this product becomes a waste, it does not meet the criteria of a hazardous waste as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, (i.e. D001 through D017) nor is it listed under Subpart D.

As a non-hazardous liquid waste, it should be solidified before disposal to a sanitary landfill. Can be incinerated in accordance with local, state and federal regulations.

SECTION 12 ENVIRONMENTAL INFORMATION

If released into the environment, see CERCLA in Section 14.

SECTION 13 TRANSPORTATION INFORMATION

DOT PROPER SHIPPING NAME/HAZARD CODE - PRODUCT IS NOT REGULATED DURING TRANSPORTATION

SECTION 14 REGULATORY INFORMATION

The following regulations apply to this product.

FEDERAL REGULATIONS:

SECTION 14 REGULATORY INFORMATION (CONTINUED)

OSHA'S HAZARD COMMUNICATION RULE, 29 CFR 1910.1200:
Based on our hazard evaluation, the following ingredients in this product are hazardous and the reasons are shown below.

Ethoxylated nonylphenol - Eye irritant
Paraffinic/naphthenic solvent - Skin irritant

Paraffinic/naphthenic solvent = TWA 350 mg/m3
Refined Petroleum Solvent, Criteria Document, July, 1977

CERCLA/SUPERFUND, 40 CFR 117, 302:
Notification of spills of this product is not required.

SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986
(TITLE III) - SECTIONS 302, 311, 312 AND 313:

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355):
This product does not contain ingredients listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 and 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS
(40 CFR 370):
Our hazard evaluation has found this product to be hazardous. The product should be reported under the following EPA hazard categories:

XX Immediate (acute) health hazard
— Delayed (chronic) health hazard
— Fire hazard
— Sudden release of pressure hazard
— Reactive hazard

Under Section 311, submittal of MSDS's or a list of product names to the local emergency planning commission, state emergency response commission and local fire department is required after October 17, 1987 if you have:

- 10,000 pounds or more of a hazardous substance, or
- 500 pounds or the threshold planning quantity, whichever is less, of an extremely hazardous substance.

After October 17, 1989, MSDS(s), or a list of product names for all hazardous substances between zero (0) and 10,000 pounds, not previously reported, must be submitted.

SECTION 14 REGULATORY INFORMATION (CONTINUED)

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372):
This product does not contain ingredients (at a level of 1% or greater) on the List of Toxic Chemicals.

TOXIC SUBSTANCES CONTROL ACT (TSCA):
The chemical ingredients in this product are on the 8(b) Inventory List (40 CFR 710).

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA), 40 CFR 261 SUBPART C & D:
If this product becomes a waste, it does not meet the criteria of a hazardous waste.

FEDERAL WATER POLLUTION CONTROL ACT, CLEAN WATER ACT, 40 CFR 401.15 (formerly Sec. 307), 40 CFR 116 (formerly Sec. 311):
None of the ingredients are specifically listed.

CLEAN AIR ACT, 40 CFR 60, SECTION 111, 40 CFR 61, SECTION 112:
This product does not contain ingredients covered by the Clean Air Act.

STATE REGULATIONS:

CALIFORNIA PROPOSITION 65:
None of the chemicals on the current Proposition 65 list are known to be present in this product.

MICHIGAN CRITICAL MATERIALS:
This product does not contain ingredients listed on the Michigan Critical Materials Register.

STATE RIGHT TO KNOW LAWS:
This product does not contain ingredients listed by State Right To Know Laws.

SECTION 15 ADDITIONAL INFORMATION

None

SECTION 16 USER'S RESPONSIBILITY

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access

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AREA 708-305-1000

SECTION 16 USER'S RESPONSIBILITY (CONTINUED)

to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to ensure safe workplace operations. Please consult your local sales representative for any further information.

SECTION 17 BIBLIOGRAPHY

ANNUAL REPORT ON CARCINOGENS, U.S. Department of Health and Human Services, Public Health Service, PB 33-135855, 1983.

CASARETT AND DOULL'S TOXICOLOGY, THE BASIC SCIENCE OF POISONS, Doull, J., Klaassen, C. D., and Admur, M. O., eds., Macmillian Publishing Company, Inc., N. Y., 2nd edition, 1980.

CHEMICAL HAZARDS OF THE WORKPLACE, Proctor, N. H., and Hughes, J. P., eds., J. P. Lipincott Company, N.Y., 1981.

DANGEROUS PROPERTIES OF INDUSTRIAL MATERIALS, Sax, N. Irving, ed., Van Nostrand Reinhold Company, N.Y., 6th edition, 1984.

IARC MONOGRAPHS ON THE EVALUATION OF THE CARCINOGENIC RISK OF CHEMICALS TO MAN, Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1977.

PATTY'S INDUSTRIAL HYGIENE AND TOXICOLOGY, Clayton, G. D., Clayton, F. E., eds., John Wiley and Sons, N. Y., 3rd edition, Vol. 2 A-C, 1981.

REGISTRY OF TOXIC EFFECTS ON CHEMICAL SUBSTANCES, U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1983 supplement of 1981-1982 edition, Vol. 1-3, OH, 1984.

Title 29 Code of Federal Regulations Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA).

THRESHOLD LIMIT VALUES FOR CHEMICAL SUBSTANCES AND PHYSICAL AGENTS IN THE WORKROOM ENVIRONMENT WITH INTENDED CHANGES, American Conference of Governmental Industrial Hygienists, OH.

PREPARED BY: Ricky A. Stackhouse PhD., Toxicologist
DATE CHANGED: 05/19/89 DATE PRINTED: 12/04/90

NALCO CHEMICAL COMPANY ONE NALCO CENTER • NAPERVILLE, ILLINOIS 60563-1198
AREA 708-305-1000

MTM Chemicals

In the event of a chemical emergency call CHEMTREC (800) 424-9300

MTM Chemicals, Inc.
Columbus Division

1979 Atlas Street
Columbus, OH 43228
Telephone: (614) 876-3637
Fax: (614) 876-9532

MATERIAL SAFETY DATA SHEET

I. PRODUCT INFORMATION

TRADE NAME:	DISPARLURE	CAS #:	29804-22-6
Chemical Name:	cis-2-decyl-3-(5-Methyl hexyl)-oxirane	RTECS #:	RR0473000
Synonyms:	None	TSCA:	On Public List
Formula:	$C_{19}H_{38}O$		
Molecular Wt.:	282.57		

II. HAZARDOUS INGREDIENTS

cis-7,8-Epoxy-2-methyl octadecane	>95%	2-methyl-trans-7,8-octadecane	<1%
2 methyl cis-7,8-Octadecene	<1%	2-methyl-7-Octadecyne	<0.5%
2 methyl octadecane	<1%		

III. PHYSICAL DATA

Boiling Pt @ 0.25 mmHg	146 - 148°C (294.8 - 298.4°F)	Melting Pt.	Not Determined
Specific Gravity.(H_2O=1)	Not Determined	Vapor Pressure	Not Determined
Vapor Density (Air=1)	Not Determined	Solubility in H_2O:	Insoluble
Volatiles by Vol.	<0.5%	Evap. Rate (Butyl Acetate=1)	Not Determined
Appearance and odor:	Colorless to slight straw color liquid		

IV. FIRE AND EXPLOSION DATA

Flash Point: >100°C (212°F) Flammable Limits in Air: Not Established
Extinguishing Media: CO_2, Dry Chemical, Foam
Special Fire Fighting Procedures: Wear self-contained breathing apparatus and full protective clothing to prevent contact with skin and eyes.
Unusual Fire & Explosion Hazard: None Known

V. HEALTH HAZARD INFORMATION

Toxicology:	Acute Toxicity	orl-rat:	LD50	>34600 mg/kg	TXAPA9 31:421, 1975
		inh-rat:	LC50	>5000 mg/m3	TXAPA9 31:421, 1975
		skn-rab:	LD50	>2025 mg/kg	Toxicology & Applied Pharm. 31:421, 1975

EPA FIFRA 1988 - Pesticide subject to registration.
Repeated exposure may lead to sensitization.

Effects of Overexposure -
Acute Overexposure: Irritant
Chronic Overexposure: Not Known

Emergency and First Aid Procedures:
Eyes: Flush with copious amounts of water for at least 15 minutes. Assure adequate flushing by separating the eyelids with fingers. Consult a physician.
Skin: Wash with copious amounts of water for at least 15 minutes. Remove contaminated clothing and shoes and wash before wearing. Consult physician.
Inhalation: Remove to fresh air and monitor breathing. If breathing becomes difficult or signs of toxicity exists, consult physician. If breathing stops, give artificial respiration and consult physician.
Ingestion: Consult the local poison center and a PHYSICIAN.

VI. REACTIVITY DATA

Conditions Contributing to Instability: In the presence of acids and bases, eposice ring will open up.
Incompatibility: Strong oxidizing agents; Strong Bases.
Hazardous Decomposition Products: in the presence of acids or bases, epoxide will open up.
Conditions Contributing to Hazardous Polymerization: N/A

VII. SPILL OR LEAK PROCEDURES

Steps to be Taken if Material is Released or Spilled: Evacuate area and ventilate. Wear protective equipment as outlined below. Carefully sweep-up, avoid raising dust, place in an appropriate container and hold for appropriate disposal. Wash spill site.

Neutralization Chemicals: N/A

Waste Disposal Method:

Dissolve or mix with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber. Note: Observe all Federal, State and Local Laws.

VIII. SPECIAL PROTECTION INFORMATION

Ventilation Requirements: Adequate ventilation required.
Personal Protective Equipment -
Respiratory (specify in detail): NIOSH/MSHA approved respirator
Eye: Laboratory safety glasses or goggles
Gloves: Neoprene or rubber or latex
Other Clothing and Equipment: Lab coat or Tyvek Suit.

IX. SHIPPING INFORMATION

Fire: 1 Health: 1 Reactivity: 0 Sp. Hazard: None
HM181: N/A Hazard Class or Div - N/A Packaging Group - N/A Labels Req- N/A
UN ID Number: Non-Flammable Liquid, NOS
SARA Title III (RQ): None CERCLA: None

X. SPECIAL PRECAUTIONS

Store in a tightly closed container in a dry, cool area. Avoid contact with material.
Avoid prolonged or repeated exposure. Lab should be equipped with a safety shower and an eye wash station. Wash thoroughly after handling material. Material should only be handled by qualified, experienced professionals.

CAUTION: Handle with care. The toxicological and physiological properties of this chemical have not been fully determined. Persons handling this chemical should avoid skin contact. Avoid eye contact and breathing vapors. Wear chemical splash goggles and chemical respirator with organic vapor cartridge when handling. NOTICE: Some of the information contained herein has been compiled from sources not under the control of MTM Chemicals, Inc. ("MTM Chemicals"). Although MTM Chemicals, Inc. believes the sources to be accurate and reliable, the description of the properties of certain substances may vary. MTM Chemicals, Inc. expressly disclaims liability for any injury or loss arising from the use of this information or the material described. The information contained herein will not necessarily be complete or accurate in all cases since the use's particular circumstances may require additional data. It is the responsibility of the user to determine the best precautions for the user's safe handling and use of this product. The information contained herein relates only to the specific material designed and not to the material in combination with any other substance. Federal and State regulations may govern the product's use. It is the user's responsibility to be aware of and comply with all applicable regulations. MTM Chemicals, Inc. make no warranties expressed or implied, including but not limited to implied warranties of merchantability and fitness for a particular purpose with respect to the material described herein.

MATERIAL SAFETY DATA SHEET

NALCO

PRODUCT

NALCO 93SD155 STICKER EXTENDER

Emergency Telephone Number

Medical (800) 462-5378 (24 hours) (800) I-M-ALERT

SECTION 1 PRODUCT IDENTIFICATION

TRADE NAME: NALCO 93SD155 STICKER EXTENDER
DESCRIPTION: An aqueous acrylamide/acrylate polymer

NFPA 704M/HMIS RATING 1/1 HEALTH 1/1 FLAMMABILITY 0/0 REACTIVITY 0 OTHER
0=Insignificant 1=Slight 2=Moderate 3=High 4=Extreme

SECTION 2 HAZARDOUS INGREDIENTS

Our hazard evaluation of the ingredient(s) under OSHA's Hazard Communication Rule, 29 CFR 1910.1200 has found none of the ingredient(s) hazardous.

SECTION 3 PRECAUTIONARY LABEL INFORMATION

CAUTION: May cause irritation to skin and eyes. Avoid contact with skin, eyes, and clothing. Avoid prolonged or repeated breathing of vapor. Use with adequate ventilation. Do not take internally.

Empty containers may contain residual product. Do not reuse container unless properly reconditioned.

SECTION 4 FIRST AID INFORMATION

EYES: Flush with water for 15 minutes. Call a physician.
SKIN: Wash thoroughly with soap and rinse with water. Call a physician.
INGESTION: Do not induce vomiting. Give water. Call a physician.
INHALATION: Remove to fresh air. Treat symptoms. Call a physician.

NOTE TO PHYSICIAN: Based on the individual reactions of the patient, the physician's judgment should be used to control symptoms and clinical condition.

CAUTION: If unconscious, having trouble breathing or in convulsions, do not induce vomiting or give water.

SECTION 5 HEALTH EFFECTS INFORMATION

PRIMARY ROUTE(S) OF EXPOSURE: Eye, Skin

EYE CONTACT: May cause irritation with prolonged contact.
SKIN CONTACT: May cause irritation with prolonged contact.
INHALATION: Prolonged inhalation of mist or vapor may cause irritation.

SYMPTOMS OF EXPOSURE: A review of available data does not identify any symptoms from exposure not previously mentioned.

NALCO CHEMICAL COMPANY ONE NALCO CENTER • NAPERVILLE, ILLINOIS 60563-1198
AREA 708-305-1000

SECTION 5 HEALTH EFFECTS INFORMATION (CONTINUED)

AGGRAVATION OF EXISTING CONDITIONS: A review of available data does not identify any worsening of existing conditions.

SECTION 6 TOXICOLOGY INFORMATION

TOXICITY STUDIES: No toxicity studies have been conducted on this product.

SECTION 7 PHYSICAL AND CHEMICAL PROPERTIES

COLOR: Milky white	FORM: Liquid	
DENSITY:	8.6 lbs/gal.	
SPECIFIC GRAVITY:	8.4-8.7 @ 75 Degrees F	ASTM D-1298
pH (NEAT) =	6.0-7.0	ASTM E-70
VISCOSITY:	1,500-3,500 cps @ 75 Degrees F	ASTM D-2983
FLASH POINT:	None	

NOTE: These physical properties are typical values for this product.

SECTION 8 FIRE AND EXPLOSION INFORMATION

FLASH POINT: None

EXTINGUISHING MEDIA: Not applicable. Use extinguishing media appropriate for surrounding fire.

UNUSUAL FIRE AND EXPLOSION HAZARD: If the water is driven off, the remaining organics may be ignitable.

Product may spatter if temprature exceeds 212 Degrees F.

SECTION 9 REACTIVITY INFORMATION

INCOMPATIBILITY: Avoid contact with strong oxidizers (eg. chlorine, peroxides, chromates, nitric acid, perchlorates, concentrated oxygen, permanganates) which can generate heat, fires, explosions and the release of toxic fumes.

THERMAL DECOMPOSITION PRODUCTS: In the event of combustion CO, CO2, may be formed. Do not breathe smoke or fumes. Wear suitable protective equipment.

SECTION 10 PERSONAL PROTECTION EQUIPMENT

RESPIRATORY PROTECTION: Respiratory protection is not normally needed since the volatility and toxicity are low. If significant mists are generated, use either

SECTION 10 PERSONAL PROTECTION EQUIPMENT (CONTINUED)

a chemical cartridge respirator with a dust/mist prefilter or supplied air.

For large spills, entry into large tanks, vessels or enclosed small spaces with inadequate ventilation, a pressure-demand, self-contained breathing apparatus is recommended.

VENTILATION: General ventilation is recommended.

PROTECTIVE EQUIPMENT: Use impermeable gloves and chemical splash goggles when attaching feeding equipment, doing maintenance or handling product. Examples of impermeable gloves available on the market are neoprene, nitrile, PVC, natural rubber, viton and butyl (compatibility studies have not been performed).

The availability of an eye wash fountain and safety shower is recommended.

If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse.

SECTION 11 SPILL AND DISPOSAL INFORMATION

IN CASE OF TRANSPORTATION ACCIDENTS, CALL THE FOLLOWING 24-HOUR TELEPHONE NUMBER (800) I-M-ALERT or (800) 462-5378.

SPILL CONTROL AND RECOVERY:

Small liquid spills: Contain with absorbent material, such as clay, soil or any commercially available absorbent. Shovel reclaimed liquid and absorbent into recovery or salvage drums for disposal. Refer to CERCLA in Section 14.

Large liquid spills: Dike to prevent further movement and reclaim into recovery or salvage drums or tank truck for disposal. Refer to CERCLA in Section 14.

For large indoor spills, evacuate employees and ventilate area. Those responsible for control and recovery should wear the protective equipment specified in Section 10.

DISPOSAL: If this product becomes a waste, it does not meet the criteria of a hazardous waste as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D.

As a non-hazardous liquid waste, it should be solidified with stabilizing agents (such as sand, fly ash, or cement) so that no free liquid remains before disposal to an industrial waste landfill. A non-hazardous liquid

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SECTION 11 SPILL AND DISPOSAL INFORMATION (CONTINUED)

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waste can also be incinerated in accordance with local, state and federal regulations.

SECTION 12 ENVIRONMENTAL INFORMATION

If released into the environment, see CERCLA in Section 14.

SECTION 13 TRANSPORTATION INFORMATION

PROPER SHIPPING NAME/HAZARD CODE - (DEPENDENT UPON MODE, PACKAGE) PRODUCT IS NOT REGULATED DURING TRANSPORTATION

SECTION 14 REGULATORY INFORMATION

The following regulations apply to this product.

FEDERAL REGULATIONS:

OSHA HAZARD COMMUNICATION RULE, 29 CFR 1910.1200:
Based on our hazard evaluation, none of the ingredients in this product are hazardous.

CERCLA/SUPERFUND, 40 CFR 117, 302:
Notification of spills of this product is not required.

SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 (TITLE III) - SECTIONS 302, 311, 312 AND 313:

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355):
This product does not contain ingredients listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 and 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370):
Our hazard evaluation has found that this product is not hazardous under 29 CFR 1910.1200.

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372):
This product does not contain ingredients on the List of Toxic Chemicals.

TOXIC SUBSTANCES CONTROL ACT (TSCA):
The chemical ingredients in this product are on the 8(b) Inventory List (40 CFR 710).

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA), 40 CFR 261 SUBPART C & D:

SECTION 14 REGULATORY INFORMATION (CONTINUED)

Consult Section 11 for RCRA classification.

FEDERAL WATER POLLUTION CONTROL ACT, CLEAN WATER ACT, 40 CFR 401.15/ formerly Sec. 307, 40 CFR 116/formerly Sec. 311:
None of the ingredients are specifically listed.

CLEAN AIR ACT, Sec. 111 (40 CFR 60), Sec. 112 (40 CFR 61, 1990 Amendments), Sec. 611 (40 CFR 82, CLASS I and II Ozone depleting substances):
This product does not contain ingredients covered by the Clean Air Act.

STATE REGULATIONS:

CALIFORNIA PROPOSITION 65:
Formaldehyde, known to the State of California to cause cancer, is present as an impurity or residue.

MICHIGAN CRITICAL MATERIALS:
This product does not contain ingredients listed on the Michigan Critical Materials Register.

STATE RIGHT TO KNOW LAWS:
The following states identify the ingredient(s) shown below as hazardous:

Massachusetts, Pennsylvania - Sodium sulfate

INTERNATIONAL REGULATIONS:

This is not a WHMIS controlled product under The House of Commons of Canada Bill C-70.

SECTION 15 ADDITIONAL INFORMATION

None

SECTION 16 USER'S RESPONSIBILITY

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to ensure safe workplace operations. Please consult your local sales representative for any further information.

SECTION 17 BIBLIOGRAPHY

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Title 29 Code of Federal Regulations Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA).

THRESHOLD LIMIT VALUES FOR CHEMICAL SUBSTANCES AND PHYSICAL AGENTS IN THE WORKROOM ENVIRONMENT WITH INTENDED CHANGES, American Conference of Governmental Industrial Hygienists, OH.

PREPARED BY: Ricky A. Stackhouse, PhD., Toxicologist
DATE CHANGED: 03/30/94 DATE PRINTED: 05/03/94

MATERIAL SAFETY DATA SHEET

I. IDENTIFICATION OF PRODUCT

LOVELAND INDUSTRIES, INC.
P. O. BOX 1289
GREELEY, COLORADO 80632

EMERGENCY PHONE NUMBERS 1-800-424-9300 CHEMTREC
1-303-356-8920 LOVELAND IND.
CALL CHEMTREC 24 HOURS A DAY @ 1-800-424-9300

TRADE NAME: BOND
CHEMICAL NAME: Carboxylated Synthetic Latex (combination synthetic latex and primary aliphatic oxyalkylated alcohol)

II. HAZARDOUS COMPONENTS OF MIXTURES

COMPONENT	CAS #	%	TLV(UNITS)
NONE			

III. PHYSICAL DATA

BOILING POINT:	212F	VAPOR DENSITY(AIR=1):	Not Est.
BULK DENSITY:	8.41#/Gal	% VOLATILE BY VOL:	45%
SPECIFIC GRAVITY:	1.01g/ml	APPEARANCE:	White Emulsion
SOLUBLE IN WATER:	Yes	ODOR:	Slight Ammonia

VAPOR PRESSURE (mm OF Hg) @ 20 D C: Not Est.

IV. FIRE & EXPLOSION HAZARD DATA

FLASH POINT (TEST METHOD):	Not Est.
FLAMMABLE LIMITS (UEL AND LEL):	Not Est.
EXTINGUISHING MEDIA:	Water spray/fog, Foam, Dry Chemical, CO2.
SPECIAL FIRE FIGHTING PROCEDURES:	Wear protective clothing.
UNUSUAL FIRE AND EXPLOSION HAZARD:	None known

V. REACTIVITY DATA

STABILITY:	Stable
CONDITIONS TO AVOID:	None
INCOMPATIBILITY (MATERIALS TO AVOID):	Avoid multivalent transition metal ions as they will cause coagulation. Will also coagulate under low pH conditions.
HAZARDOUS DECOMPOSITION PRODUCTS:	None Known
HAZARDOUS POLYMERIZATION:	Will not occur

VI. HEALTH HAZARD DATA

EFFECTS OF OVEREXPOSURE: Animal studies indicate minimal toxicity through oral or dermal route. Eye and skin exposure indicated as minimally irritating.

EMERGENCY AND FIRST AID PROCEDURES:

EYES: Flush with water for 15 minutes, then get medical attention.

SKIN: Remove contaminated clothing. Wash with soap and water. Get medical attention if irritation persists.

INGESTION: First aid is not normally required, if symptoms persist get medical attention.

INHALATION: Remove victim to fresh air. Apply artificial respiration if necessary.

CARCINOGEN STATUS: Not listed by NTP, IARC or ACGIH.

VII. SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED: Pick up with absorbant material and place in a container for proper disposal in accordance with all Federal, State and Local Regulations.

WASTE DISPOSAL METHOD: Do not contaminate water, food, or feed by storage or disposal. Dispose of in an approved waste disposal facility in accordance with all Federal, State, and Local Regulations.

CONTAINER DISPOSAL: Triple rinse (or equivalent) adding rinse water to spray tank. Offer container for recycling or dispose of in a sanitary landfill, or by other procedures approved by the appropriate authorities.

VIII. SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION: Wear a NIOSH/MSHA approved respirator if necessary.

VENTILATION:	LOCAL:	Recommended	SPECIAL:	None
	MECHANICAL:	Not required	OTHER:	None

PROTECTIVE GLOVES: Wear rubber or impervious gloves.

EYE PROTECTION: Wear goggles or a face shield.

OTHER PROTECTION: Full body covering clothing.

IX. SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN STORAGE AND HANDLING: Store in a cool dry place. Keep in original container, tightly closed. Do not reuse empty container.

OTHER PRECAUTIONS: Keep out of reach of children. Always launder contaminated clothing before reuse.

X. REGULATORY INFORMATION

Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III. SARA 313 requires submission of annual reports of release of toxic chemicals that appear in 40 CFR 372.
Components which could require reporting are: None.

SARA TITLE III HAZARD CATEGORY

IMMEDIATE:	Yes	FIRE:	No	REACTIVITY:	No
DELAYED:	No	SUDDEN RELEASE OF PRESSURE:			No
FREIGHT CLASS:	ITEM 102120	CLASS 60			
DOT REGULATION:	Not Regulated				

Legal responsibility is assumed only for the fact that all studies reported here and all opinions are those of qualified experts. Buyer assumes all risks & liability. He accepts & uses this material on these conditions. He must have a copy of this MSDS where this material is handled.

Date of Issue: 10/25/90 Supercedes: 8/19/90